MANUAL TRAINING
FOR COMMON SCHOOLS

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AN ORGANIZED COURSE IN WOOD-WORKING

BY

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AUTHOR'S PREFACE

In preparing this book on "Manual Training" the author has attempted to be thorough rather than complete. No attempt has been made to add anything new to the subject-matter, but only to arrange well-known facts so that they will offer as systematic and complete a course of study as is offered in any of the older organized courses.

The arrangement of the text as herein presented is the direct result of five years' teaching the subject of wood-working to beginning classes. This class work was preceded by a number of years of shop work as a journeyman machinist and a factory foreman, as well as by a four years' college course in science and engineering.

Help in preparing the text has been gleaned from so many fields that it would be impossible to make direct mention of all who have given valuable assistance. The author wishes, however, to acknowledge the aid given by Mr. Charles E. Emmerich, principal of the Indianapolis Manual Training High School, and Mr. Paul W. Covert, head of the manual training department, who have allowed such freedom in the conduct of classes that it has been possible to make all parts of the work measure up to a class-room test.

Acknowledgment is due Mr. Otto Stark, head of the art department of the Indianapolis Manual Training High School, for his earnest and careful criticism of the models, drawings, and photographs. This criticism has added much to the value of the text.

The final drawings from which the cuts were executed were made by Mr. Edward Stark, of Indianapolis.

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E. G. ALLEN.

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INTRODUCTION

The child is both physical and spiritual, and education must, therefore, consider both body and soul. Grace and beauty in form, strength and health of body, and skill in execution, are all matters that must be provided for in the course of study. The æsthetic and hygienic phases of child life have been recognized, and when the practical side receives the attention which it merits, head, hand, and heart will become allies in education. Every child must be taught to work, and to the degree in which the home neglects this part of his education, the school must, whether it would or not, take up this phase of his training and carry it to completion. The course of study of the future will provide a complete system of manual training through the grades and high school.

ADJUSTMENT OF WORK OF HEAD AND HAND

When this course is finally perfected it will be a complete adjustment of the work of head and hand. All hand work will supplement head work. All mere "busy" work, that is to say, work without educative value, placed in the course of study to keep the children quiet, will be eliminated. Manual training, that is, work that will put the children in possession of themselves and tend to fit them for the work that they are likely to do in life, will have passed the fad and experimental stage and will be part and parcel of the educative process.

It may be that the so-called academic subjects, such as grammar, geography, and arithmetic, will be taught more intensively, and that fully as much time will be given to the hand work as is given to the

former. The element of utility will determine almost wholly the work chosen and the stress to be placed upon it. Children are easily interested in doing things that are really worth while. Work that becomes burdensome to either teacher or pupil loses much of its educative value. It may be that in the schools of the future the academic and manual departments will be carried on by different teachers, capable of doing their own work well, but able to relate the two lines of instruction. Until this can be realized, however, the schools as at present organized must do what they can toward training the hand, and a little ingenuity on the part of the teacher can bring surprising results from very meagre resources.

SOME PRACTICAL MANUAL TRAINING WORK

The following suggestions can be carried out in the grades, especially by teachers who are interested in any phase of manual or industrial education.

The possibilities of drawing in legitimate directions are almost unlimited. Accurate constructive work in drawing is of the highest educative value, both in itself and for the aid it may render the other subjects. The teacher who draws well and makes frequent use of the blackboard out-distances all of her associates in the profession who cannot draw. Every phase of nature study furnishes work in drawing. Geography can be made doubly interesting and effective with pencil and chalk. Arithmetic affords constant opportunity for constructive work. All teachers should learn to teach drawing, if for no other reason than to be able to use it in other departments of school work.

Then there is apparatus of all kinds to make, and home-made apparatus is the very best kind. It not only gives the children excellent drill in practical manual training work, but it supplies the school with needed apparatus at the least possible cost.

One of the most valuable assets in a teacher's equipment is a set of tools and the ability to use them. It is no mean accomplishment to be able to design and construct a plain gate. It takes commendable skill to make a simple picture frame, and the different ways of fitting pieces into perfect squares call for much practice. A square, a saw, a hammer, a chisel or two, a brace and a bit will furnish an admirable outfit. The making of a simple piece of apparatus, a box, gate, fence, shelf, or frame for the boys may show the way. As simple an equipment looking toward household industry may serve the same purpose for the girls. There is the designing, cutting, and making of simple garments, to say nothing of other activities in the home which make their chief and lasting appeal to girls. All these and more may be attempted, and may be made to supplement the work in the traditional subjects of study. Besides furnishing the very best of manual training work, they add interest and charm to the older lines of study.

With intensive, interesting, complete work, based upon the home life and industry, running through the grades, and the elimination of all dead, mechanical work based upon tradition, there would be time for much real manual training: bench work for the boys, much closer to the trades than manual training in the high school, and sewing and cooking for the girls. Such work carried through the grades would make more intensive, efficient work possible, and would be the means of attracting a larger number of pupils from the grades into the high school. In the high school, work may be undertaken looking toward higher, more systematic courses in college.

EDUCATION MUST BE INDUSTRIAL AS WELL AS ACADEMIC

The problem of education is industrial as well as academic. Of the thirty-two million bread-winners in this country, some thirty million must work with their hands. Education must, therefore, exalt the dignity of labor; it must teach habits of industry; it must

give ability to apply one's self to the problem in hand; it must meet the demand for accurate, skilful work. The school work must be more practical for the great army of children in the grades, four-fifths of whom never reach the high school.

One great defect in school work in this country is that we have assumed in both the grades and high school that all children are of equal ability, and that their abilities lie in the same direction, when neither assumption is true. We have not caught the notion of equal opportunity, and then gone about providing for the training of the several abilities so as to fit men and women to meet the actual conditions of life. Education has aimed, and still aims, to train the head, and not the head and hand. It has prepared for college instead of for living. It has been too bookish—adapted only to those who can follow a long educational career. It has trained men for the careers of lawyers, preachers, doctors, teachers, and leaders, though there are not enough of these positions to go around. It has prepared the bosses, and has not thought of skilled labor in the ranks. In this sense it has been practical, but it has not met the needs of the common people, the overwhelming majority of whom must continue to work with their hands. We must make more adequate provision in our schools for the education of those who must begin early to earn their living.

BOYS AND GIRLS SOON TO BECOME BREAD-WINNERS

One of the greatest criticisms that can now be made upon our schools, city, town, and country, is that no tangible, vital relation exists between school education and the other essential forms of education. Since the home and the farm and the shop no longer train the children efficiently, there is a greater call upon the school to take up the work so cast off. But the school has not assumed the responsibility nor met the new demand, and it cannot do so as at present organized.

The great majority of the children in school to-day will shortly need to become bread-winners, and they will have to work with their hands. They will take up every form of industry. The farm and factory and mine and shop will demand skilled labor. It is doubtful whether the schools of town, city, or country are doing the best that can be done for these children. No impractical thing, nothing that raises impossible ideals and false hopes, nothing that belittles or ignores honest work and lessens efficiency, should have time and place in the schools. The nature and needs of the particular child must determine what shall be done.

If this nation is to endure, all of the people must be educated. If they are to be prosperous and happy, they must be intelligent, temperate, industrious, skilful, and constantly employed. These qualities come only with the right kind of education. They make for manhood and womanhood.

The proper introduction of manual and industrial training in the grades and in the high school will be the means of keeping larger numbers of boys and girls in the schools through both the grades and the high schools. It will raise the average intelligence in the country, and will direct larger numbers of our young people toward the higher institutions of learning.

So, in the way indicated, industrial training is to get a foothold in the schools. Its development depends upon the teacher. It is a question of the teacher's ability to use the material at hand—material furnished by the home life of the child and the industrial life of the community. A consideration of experiences in the shop and on the farm will furnish the very best opportunity for teaching the dignity of labor, and for showing the advantages of farm life and other industries. It will open a way for showing how to proceed intelligently in any occupation. The main thing is to teach the boy and girl how to attack a problem and to carry it to a successful solution. And they need to be taught that skilful execution is one of the chief

factors in success of any kind. From the stand-point of character-building, it matters but little upon what problems pupils work, but the attitude displayed and the habits formed as they attempt a solution are matters of great moment. Intelligent attack, orderly procedure, skilful execution, painstaking completion, habits of industry, good, honest work, respect for labor, the ability to do things —these are the qualities that belong to real education.

THE WORK OFFERED IN THIS BOOK

The work offered in the following pages is intended for the boys in the seventh and eighth grades, and the first and second years in the high school.

It will be found valuable to teachers of these grades, both for its method and its subject-matter. It is a course of study in wood-work, particularly, for the boys of the grades named, while at the same time it gives enough of method and device and direction to make successful work possible without making it burdensome. It does not presuppose on the part of the teacher special training in the manual arts, but, on the contrary, brings to the untrained teacher the help of a specialist, who furnishes in the following pages an abundance of carefully graded problems that admit of solution in shops of simple construction and equipment. Given a teacher of average ability, and some appreciation of the meaning of the new movement in education, and this book will quickly find its proper place in the industrial development of the boys of the community.

F. A. COTTON.

NOTES TO TEACHERS

TEACHERS should recognize the fact that the principles of pedagogy used in presenting the academic subjects are the basis of all teaching, and that they should be applied to the teaching of industrial subjects.

The first and indeed the greatest difficulty encountered in teaching wood-work is to begin in such a way that the child will do a definite thing and at the same time not be swamped in the number and variety of tools and operations which he must use. To that end it will be well to keep the following well-known facts in mind.

1. The work must be definite and must proceed from the simple to the complex by easy and successive stages.

2. No work should be assigned to a child which it cannot do in a reasonable time and with some degree of success.

3. One new fact or one new operation is all that should be included in any assignment, and it is by no means necessary that every assignment include something new.

At first the interest of the pupils is centred in the tool, for it is new to them. The teacher who does not take advantage of the newness of the tools to develop some little skill in their use and a knowledge of the working parts, before the novelty is gone, places upon himself and the pupil a dead load which must be lifted later.

In the beginning the child has no standard of accuracy. He does not know the requirements of a working face or a joint edge, or when a joint is well fitted, and such knowledge is difficult to get from a book.

The class demonstration should furnish this information. The teacher should be careful, however, not to make a demonstration too long, and should leave a sample of his own work where the pupil can refer to it as a standard.

The knowledge and skill of the teacher should always be an inspiration to the class.

No pupil should be allowed to begin a piece of work, however simple, until he has a clear statement of the problem.

The first four problems in the suggested course of study are arranged so as to centre the attention of the pupil on a single tool and its use. The frequent references made to the main text call the attention of the pupil to the fact that the first problems do not include all that is necessary for them to know. They will soon realize that they are enjoying a handicap and will not object to having it gradually removed.

One of the most difficult problems for the teacher is to aid the pupil in selecting a suitable article to make. As a rule, the pupil will want to make something which requires much more time and skill than he has. To begin a piece which the pupil is not able to finish leads to discouragement and waste of time and material. On the other hand, the work must be serious enough to call for his best effort and the result must appeal to the pupil as being worth while. In the beginning classes it is believed that the freedom of choice from a small group of models or drawings will insure better class teaching and more direct results than will come from the use of a larger group.

The subject of trees and their uses should be the object of outside reading.

The growth of trees is considered in any complete work on botany.

Publications of the government department of forestry furnish valuable information on the subject of forestry and lumbering. These publications are free. The encyclopædia will give much interesting information on lumbering and any particular kind of tree.

The school library or the shop reading-room should be supplied with catalogues of builders and cabinet hardware and lists of lumber which are on sale in the locality.

When all possible has been said, the text and the course of study are but tools in the hands of the teacher, who is the master mechanic.

E. G. Allen.

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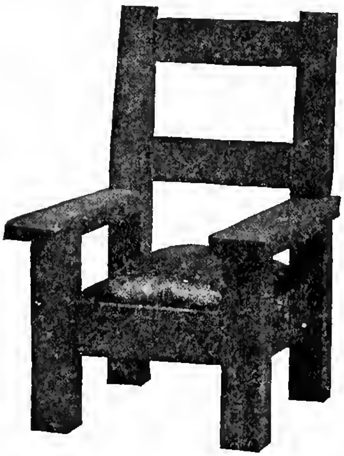
CHAPTER I

WOOD-WORKING

IF we look at any piece of wood-work we see at once that it consists of wood modelled or shaped to meet certain conditions. The wood, the raw material, is changed by the use of the tool to meet the condition of the product. We have before us, then, the three elements of wood-work—the Product, the Material, and the Tool. Try as we may, we cannot get away from these three. We cannot do any one thing in wood without bringing in all three. The thoughtful wood-worker—that is, the one who plans or designs the product and carries it through to completion—must know certain fundamental things about the three elements spoken of above.

Three elements of wood-work.



The questions to answer are: Can these facts be grouped into a systematic whole so that each step in the process of construction will appear in the proper relation to the others; and is there a fund of knowledge that is general which can be used in a modified form to solve any special problem?

General fund of knowledge.

It will be the object of this and succeeding chapters to answer these questions and finally to make such an arrangement of the facts as will meet the needs of the several school grades in which the subject of wood-work may be taught.

Characteristics of wood.

Since wood is to be our material, we must get a piece of wood and examine it to learn its most noticeable characteristics. If we look at the wood closely, we shall see that it is made up of fibres that run parallel. If we cut it with a knife, we note at once that it cuts much more easily in the direction of the fibre than it does at right angles to it.

Two kinds of tools.

If we wish to shape the piece of wood to meet any required condition, and look for the necessary tools with which to do it, we shall find two types, or kinds, of saws and two kinds of planes, or at least the parts of the saw and plane which cut the wood are made of different shapes. One shape is made for cutting in the direction of the fibre, or grain, and one at right angles to it. The nature of the change we wish to make in the piece of wood will determine the kind of tool we shall select.

Product, Material, Tool

Thus, from the very first we must consider the *product*, the *material*, and the *tool*, and in the order named. Too much emphasis cannot be put upon this order of procedure, the *product*, the *material*, and the *tool*.

Definite order of procedure.

Some will say, and, in fact, some proceed as though the product were the last thing to be thought of. In the natural order of things our desire or want leads to some particular thing, and with the definite end in view we start out to find ways and means of producing what we want. The nature of the desire will determine the kind of material and the tools to use. The order of procedure then is simply this: State your problem—select your material—choose your tools.

Inasmuch as we are beginners in wood-work, our product must be simple. It will, therefore, call for only a simple statement, will need but little material, and will require the use of the most common tools.

Suppose we are working in a lumber yard and receive the following order: Send one piece of pine, two inches thick, four inches wide, and two feet long. We have here the simplest problem that we could have. It includes but one piece of wood and gives in plain terms the necessary three dimensions. If the above order included several pieces of different dimensions the statement given would be too long and too complex to follow. Because of this complexity the following form for writing an order for lumber has been adopted: Written order complex.

Please send the following, Pine: Order for bill of lumber.

1 piece 2″ x 4″ x 10′—Read: two inches by four inches by ten feet.
12 pieces 2″ x 4″ x 16′—Read: two inches by four inches by sixteen feet.
10 pieces 1″ x 12″ x 14′—Read: one inch by twelve inches by fourteen feet.

The two small marks to the right and above the figures, 2, 2, 1, and 4, 4, 12, as (″), mean inches, and the one small mark to the right and above the figures 10, 16, 14, as (′), means feet. If we notice carefully we shall see that the thickness of all the pieces is expressed by the first figure, the width by the second, and the length by the third, and that each one is placed in the proper column the same as the units, tens, and hundreds that we wish to add. There are several reasons for this form, but the best is that it is the one in common use among lumbermen, and consequently will be better understood by any one who may be called upon to fill the order. By designating the kind of material at the head of each list we avoid the necessity of writing it before each piece.

With the ability to state our problem we are ready to consider the material and the tool.

We will proceed to fill the following order: Pine or Poplar: 1 piece $1\frac{3}{4}$″ x 4″ x 24″, finished to thickness, width, and length. We First problem stated.

Measuring tools.

must measure our lumber, and if we do not have such a piece in stock we must cut it from a larger piece. The measuring instrument used is generally the two-foot rule or the carpenter's square, shown in use in Figs. 1 and 1*a*, respectively.

Divisions or graduations on ruler.

Each line on a ruler is called a *graduation* line. All of the lines are referred to as the *scale*, and we speak of the scale divisions, meaning the number of parts into which the ruler is divided. The rules used in wood-working are graduated or divided into sixteenths, eighths, quarters, and halves of an inch, and into inches.

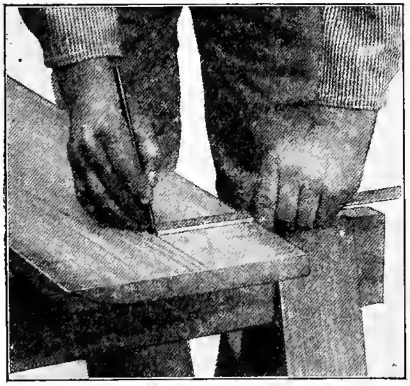


Fig. 1—Rough Lining with Pencil and Rule

Mark or lay out dimensions.

If we are to cut out a piece of wood, we must measure it and mark the measurements so that we can cut quickly and accurately without repeated measurements. The piece we are to make is to be well finished, and in making the first saw cuts some material must be left for finishing with tools which cut smoother and better than does the saw. In the present case, an eighth of an inch in thickness, one-quarter of an inch in width, and one-half of an inch in length will be sufficient material for finishing. The rough dimensions will be $1\frac{7}{8}'' \times 4\frac{1}{4}'' \times 24\frac{1}{2}''$. These rough dimensions may be marked out with the grain, with a lead-pencil and rule, as in Fig. 1. The thumb nail

Material left for finishing.

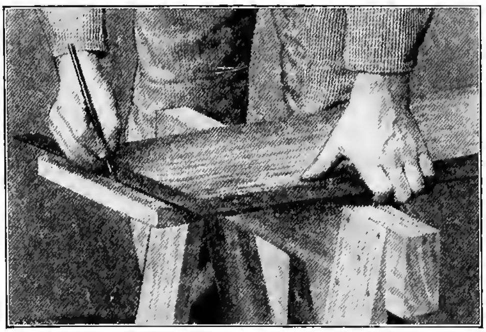


Fig. 1a—Cross Lining with Pencil and Carpenter's Square

is held against the edge of the board as a guide, the pencil is held against the end of the rule, and both hands are moved along together for the required distance. Cross lining is done with the pencil and square held as in Fig. 1*a*. When the piece is laid out or marked out we are ready to saw.

Two kinds of saws.

We have said before that saws are made in two ways—one for cutting with the grain and one for cutting at right angles to it, or, as they are called, the rip saw and the hand or crosscut saw, respectively.

The rip saw.

How can we tell one from the other? If we examine the saws carefully we shall find that one of them has teeth shaped like a row of chisels set one back of the other, as in Fig. 2.

Fig. 2—Chisel-shaped Teeth of the Rip Saw

The face or front side of each tooth is at right angles to the side of the blade. Inasmuch as the teeth of this saw are made like a chisel, we will cut the wood with a chisel and see in which direction of the grain it works best, with the grain as at *a* (Fig. 3), or across the grain as at *b* (Fig. 3).

Shape of rip saw teeth.

We find that the chip, or shaving, at *a* is smooth and clean cut, while at *b* the wood is split or broken. The test shows that the saw with the teeth shaped like the chisel will cut best with the grain. This tool is the Rip Saw.

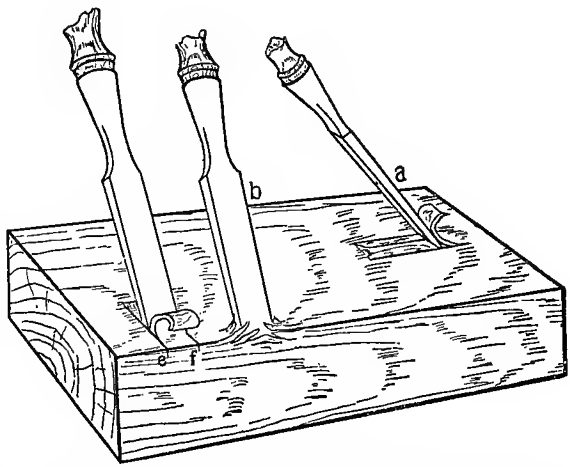


Fig. 3—Chisel Cuts Illustrating the Cutting Action of the Saw Teeth

If we take a knife and cut the fibre of the wood at *e* and *f* (Fig. 3), and then cut between these lines with a chisel, we again

get a smooth, clean cut, as at *a*, only at right angles to the grain. In this latter cut two tools, the knife and the chisel, work together.

Crosscut saw.

An examination of the handsaw or crosscut saw teeth (Fig. 4), will show how the knife and the chisel may be combined so as to cut wood at right angles to the fibre.

Shape of crosscut saw teeth.

The saw teeth represented in Fig. 4 show that the point of the first tooth (*a*) is on one side of the blade, and the adjacent point (a^2) is on the opposite side. We shall find the adjacent points alternating from one side to the other the entire length of the saw. In action, the point (*f*) will cut the fibre on one side of the blade, and a^2 will cut it on the other; each doing the work of the knife. The chip will be carried out by the chisel-shaped end, as at *a*.

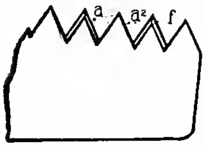


Fig. 4—Shape of Hand or Crosscut Saw Teeth

Set. Bending of saw teeth.

All saws are set, that is, the adjacent teeth are bent in opposite directions, to make the saw cut, or kerf, wider than the blade, in order to prevent the saw from sticking in the wood. (See Fig. 5.) Care should be taken not to confuse this bending with the shape of the two types of teeth.

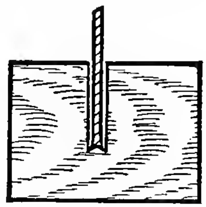


Fig. 5—Bending of Teeth to Make Saw Cut or Kerf Wider than the Blade of the Saw

This will give us sufficient knowledge to select the saws for the problem that we are to solve. The wood has been marked off or, as is usually said, is laid out, and we are now ready to saw.

Saw out rough stock.

Place the large board on a convenient rest. A pair of stands, one of which is shown in Fig. 6, called Saw Horses, are generally used. Take the rip saw in the


Fig. 6—Starting the Rip Saw

hand, with the first finger extending along the handle, as is shown in Fig. 6; this extended finger helps to hold the saw steady and to guide it. Place the other hand on the board, letting the thumb rest against the saw blade, to form a stop or guide until the cut is well started. Grip the saw firmly, but not so rigidly that the muscles are set and stiff. The cut should be made with a long, steady stroke, and the saw should be held square with the face of the board. To do this the small square, about which we shall learn more later, may be placed on the board and the blade of the saw kept parallel with the blade of the square. (See Fig. 6*a*.) The saw cuts best when held at an angle of about 45° to the face of the board, as shown in Fig. 6.

Starting the rip saw.

Squaring the saw.

Fig. 6a—Squaring the Saw

The crosscut saw is held and squared the same as the rip saw. (See Fig. 6*a*.) The first stroke, however, should be back against the teeth, that is, toward you, in order to prevent the wood from splitting on the edge. Do not bear down on a saw of any kind, and be sure to take long, steady strokes. When the piece is sawed out we are ready for finishing.

Starting the cross-cut saw.

Problem.

Our problem is to finish this piece of pine to the required dimensions, $1\frac{3}{4}'' \times 4'' \times 2'$. The order of procedure should be as follows:

Order of proceed-ure.

(1) Measure the piece to make sure it is large enough to meet the requirements. (2) Examine it carefully to see that there are no flaws that will render it worthless after we have spent valuable time upon it. (3) Select the best face. Hold it up and sight over it both from the end and from the side, to see if it is warped or twisted, or, as the carpenter would say, "To see if it is in wind." (4) Make this face a true plane by planing.

Kinds of of planes.

As has been said, we have two types of planes—one for cutting in the direction of the grain (Fig. 7), and one for cutting at right angles to it (Fig. 7*a*). How can we tell these two apart?

Even a hasty glance at these two planes will show a marked difference. The cutting part of Fig. 7 stands much more nearly perpendicular to the base of the plane than does that in Fig. 7*a*. The size

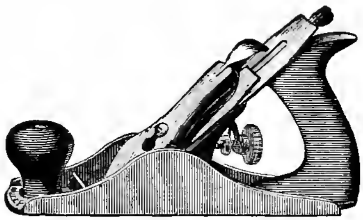


Fig. 7—Plane for Cutting with the Grain

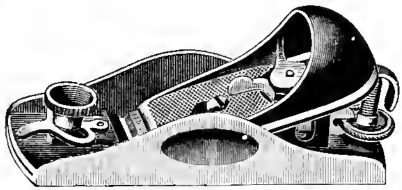


Fig. 7a—Plane for Cutting across the Grain (Block Plane)

and general shape of the two are so different that the worker will readily learn which one to use for the work in hand.

Many kinds of planes.

There are many forms and shapes of planes, but those forms which we shall need to use in the solution of our problem are all that we shall consider at the present time.

Necessity for two kinds of planes.

If we have ever done any close, accurate work with tools, we know that tools for such work must be sharp, and that if they remain sharp they must not be overworked by cutting out too much material at once, or by cutting into rough, dirty places. For this reason the woodworker has two planes very much alike, the principal difference being that the cutting part of one plane is shaped for removing a large amount of material without much care as to the condition of the surface, while the cutting part of the other is shaped to remove a small amount of material and at the same time leave the surface of the wood in a smooth, finished condition.

The cutting iron, or plane bit, for removing a small amount of material is shaped as in Fig. 8. The plane bit for removing a large

amount of material is shaped as in Fig. 8*a*. If a deep cut should be made with a plane bit like the one shown in Fig. 8, set into the wood as in Fig. 9, the wood at *a* and *b* would be split or torn from the body of the piece and leave rough, ragged edges. If we

Shape of cutting edge of plane bit.

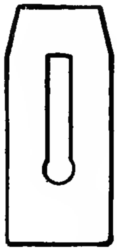


Fig. 8—Plane Bit for Removing a Small Amount of Material (Smooth Plane)

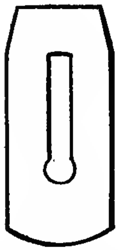


Fig. 8a—Plane Bit for Removing a Large Amount of Material (Jack Plane)

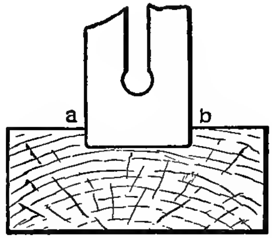


Fig. 9—Deep Cut with Smooth Plane Bit

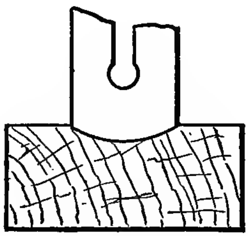


Fig. 10—Deep Cut with Jack Plane Bit

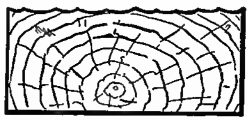


Fig. 11—Condition of Surface After Cut, as Shown in Fig. 10

cut with a bit like the one shown in Fig. 8*a*, set into the wood as in Fig. 10, the shaving would be cut throughout the entire width and the surface left uneven, as in Fig. 11, but clean cut.

We notice that the corners of the bit in Fig. 8 are slightly rounded. This is to prevent scratching. In short, the plane bit for doing rough work, the *Jack Plane*, has the cutting edge ground oval; while the cutting edge of the plane iron for doing smooth work, the *Smooth Plane*, is ground straight across with the corners slightly rounded.

Jack plane and smooth plane.

The rounding of the corners of the smooth plane is all done on the oil-stone.

Length of planes.

Ordinarily in speaking of the kind of plane the length of the base or stock enters into consideration:

Smooth Plane, 5″ to 10″
Jack Plane, 12″ to 15″
Fore Plane, 18″
Jointer Plane, 22″ to 24″

The Jack Plane is from 12″ to 15″ long only because this is a convenient length. The principal difference between it and other planes is the shape of the cutting edge of the bit or cutting iron.

Short and long planes.

There is one more question about planes in general that concerns us here. Why are some planes longer than others? If we wish to plane a surface like Fig. 12, and use the short plane, we can readily see that it will follow the surface and make it smooth, but it will not make it straight. The waves or larger inequalities will remain always the same. If we use a long plane, as in Fig. 13, it will reach over the low places, ultimately making the surface straight.

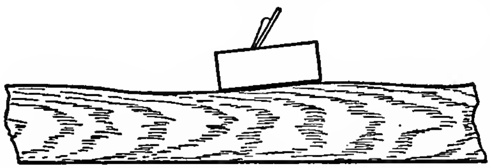


Fig. 12—Irregular Surface Planed with Short Plane

General statement for use of planes.

The following statements with regard to the use of the planes may be made: (1) Use the smooth plane on small pieces, on surfaces that have previously been made straight by the use of a long plane, and on surfaces that do not need to be made perfectly true. (2) Use the roughing plane or Jack Plane to remove a large amount of material. (3) Use the Fore Plane or the Jointer Plane for surfaces and edges

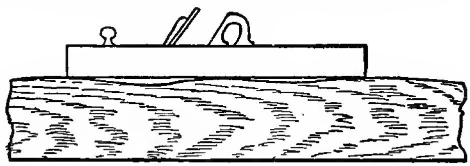


Fig. 13—Irregular Surface Cut with Long Plane

that need to be very accurate. The bits for the fore plane and jointer plane are ground the same as for the smooth plane (Fig. 8).

Learn trade vocabulary.

As the planes are used the names of the parts should be learned. The trade vocabulary should also be learned as far as possible, more by contact and necessity than by any actual drill in such terms.

With the knowledge we have of planes, we can now choose the proper ones to use in filling our order. We have measured our piece of stock, have examined it carefully and have made sure that there are no cracks, knots, or other serious defects, and have chosen the best face, page 7.

Planing the First or Working Face

A rule for measuring.

The first or working face is very important, for it is the base of all measurements, and mistakes made in this face will be carried to all the other faces. The single face as a base of all measurements makes use of a general principle which is very important in all work which requires accurate measurements. A simple statement of this principle is: In measuring, use as few starting-points as possible. For example, if we are to measure from *a* to *b*, *b* to *c*, and *c* to *d* (Fig. 14), and use *a* as a starting-point to measure *a—b;* *b* as a starting-point to measure *b—c*, and *c* to measure *c—d*, we shall have three chances to make errors in measuring from *a* to *d*, and every intermediate error will be added to every other; thus we shall be constantly adding errors. On the other hand, if we measure from *a* to *b*, from *a* to *c*, and from *a* to *d*, there will be but one chance for mistake in each measurement, and any intermediate error will not affect the measurement from *a* to *d*. Too much stress cannot be put upon this principle.

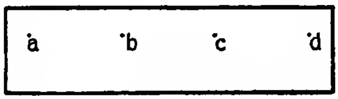


Fig. 14—Measure from as Few Points as Possible

After sighting across the face and marking the high spots with a pencil, the Jack Plane should be used to remove the rough surface,

then the smooth plane for finishing. The cutting iron, or plane bit, should be sharp and very keen, so as to remove the material or stock with the least effort, and at the same time leave the surface of the wood in good condition.

How to sharpen a plane bit.

To sharpen the bit, it should be removed from all other parts of the plane, as in Fig. 15. If the edge is blunt, or has nicks in it, it must be ground on a grindstone, as in Fig. 16; *a* represents the plane bit; *b* the grindstone, and the arrow the direction in which the wheel is turning.

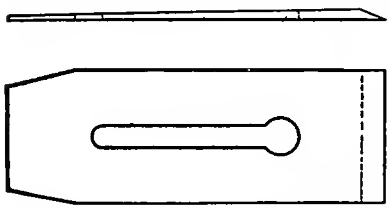


Fig. 15—Plane Bit Ready for Grinding

Shape of cutting edge.

When ground the bevel of the cutting edge should be, as in Fig. 17, *a straight line from* 1 *to* 2, *or should be slightly concave,* as in *c* (Fig. 17).

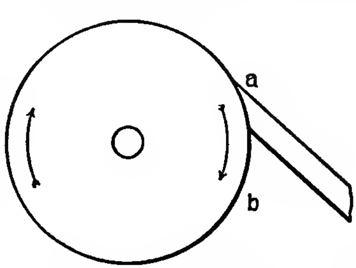


Fig. 16—Position of Plane Bit on Grindstone

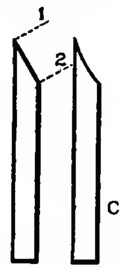


Fig. 17—Correct Bevel for Cutting Edge of Plane Bit

Grind-stone.

The grindstone is coarse and leaves a rough burr, or feathery edge, which must be removed.

Oil-stone.

This is done on the oil-stone, as in Fig. 18. Much care should be taken to keep the bevel always flat on the stone, in moving the bit from *a* to *b* (Fig. 18). Always avoid such a change of position as is shown in *a*—*b* (Fig. 19).

Principle of cutting edge.

The principle of the cutting edge of any tool is the same as the principle of the wedge. The thinner the wedge the easier it is to drive it. But the wedge as well as the tool must be thick enough to stand the strain of

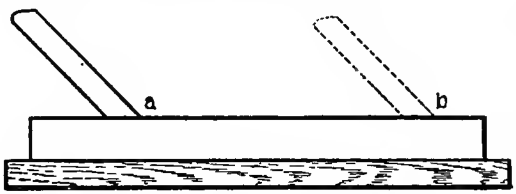


Fig. 18—Correct Method of Oil-Stoning Plane Bit

being driven or pushed into the wood, or the material that is to be split or cut. From this it will be seen that in grinding a tool to be used on hard wood the bevel would need to be more obtuse than for cutting soft wood. If we have ground a tool to the bevel (1—2) (Fig. 17), and oil-stone it as *a*—*b* (Fig. 19), instead of having the de-

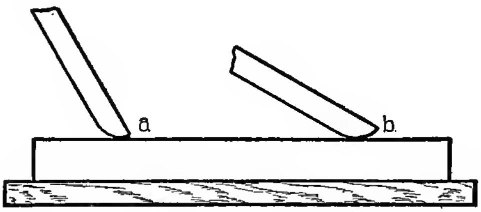


Fig. 19—Incorrect Method of Oil-Stoning Plane Bit

Fig. 20—Incorrect Oil-Stoning Changes the Angle at the Cutting Edge

sired bevel at the point, it would have a bevel as 1—2 (Fig. 20), which would be too blunt to cut well. The problem of grinding the tool and keeping it in order is one of the most difficult that the mechanic has to solve. Skill in grinding comes only after continued use of the tool.

Skill in grinding.

With the bit ground and made smooth on the oil-stone, we can now proceed to put it into the plane. In doing this, we find several parts the names and uses of which it will be well to know. The first part to be added to the bit is the plane iron cap (Fig. 21). This should be placed about one thirty-second of an inch from the cutting edge. The object of this cap is well shown in Figs. 22 and 23. If the bit is set into the wood, as in Fig. 22, without the cap, the shaving will slip up the bit as at *a*, and as the bit advances into the cut the shaving will break farther and farther ahead of the cutting edge, thus causing the wood to split in the direction of the grain. This will leave a rough face, as at *b*. If the

Plane iron cap.

Use of plane iron cap.

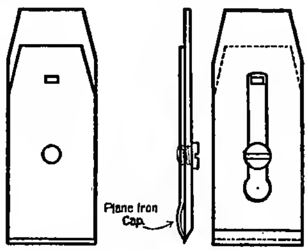


Fig. 21—Plane Iron and Cap

cap be added to the bit, set as directed above, and the bit set into the wood, as in Fig. 23, when the plane advances the shaving will strike the cap, as at *c*, and will be broken before it has leverage

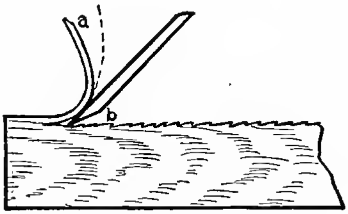


Fig. 22—Plane Bit Cutting without Cap

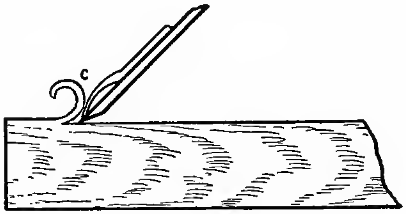


Fig. 23—Plane Bit Cutting with Cap

enough to split ahead. The fibres will be cut and the surface of the wood left smooth.

Double and single plane iron.

The bit without the cap is called the single bit, and with the cap is called the double bit.

The bit and cap are now ready to be placed in the stock. See *B*,

Fig. 24—Plane Stock, Bit and Clamping Iron Removed

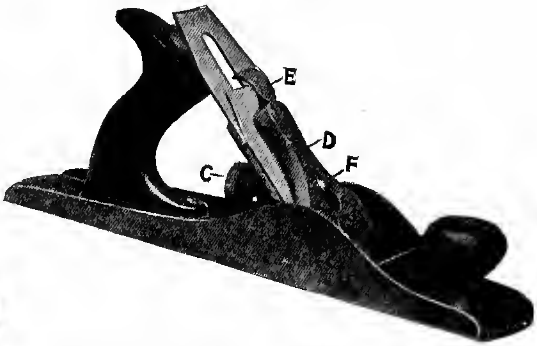


Fig. 25—Complete Plane Ready for Use

Principal parts of plane.

Fig. 24. The whole base of the plane, including the handle, is generally referred to as the *stock* of the plane. The bit should be placed in the stock, cap up. Care should always be taken not to strike the cutting

edge on any of the iron parts of the plane. Slip the clamping cap (*D*) (Fig. 25) under the screw (*F*), and push down the clamping lever (*E*) (Fig. 25). The screw (*F*) may be adjusted so that when the clamping lever (*E*) is pushed down the bit will be held firmly in place.

Adjusting the plane.

Hold the plane as in Fig. 26; move the adjusting lever (*A*) (Fig. 24) until the cutting edge of the bit is parallel with the face of the stock. Turn the adjusting nut (*C*) (Fig. 25) until the bit is drawn above the surface of the stock, then turn it slowly or gradually downward until it cuts the required shaving.

Cut thin shavings.

A very thin shaving is all that is needed. The tendency is to cut the shaving too thick and to remove too much stock from the working face.

Parts of try square.

To test this face use the Try Square (Fig. 27). The square should be held as in Fig. 28. The beam (Fig. 27) is held up to avoid the tendency to place it against the irregular unfinished edge. The square in this position is used only as a straight-edge.

Try square used as a straight-edge.

Fig. 26—Adjusting the Plane Iron

The face should be tested every two or three strokes of the plane. The object is not to remove material or stock, but to make the face a perfect plane. By holding the work toward the light one can readily see whether or not the blade of the square touches the wood across the entire face. Tests should be made every inch or two the

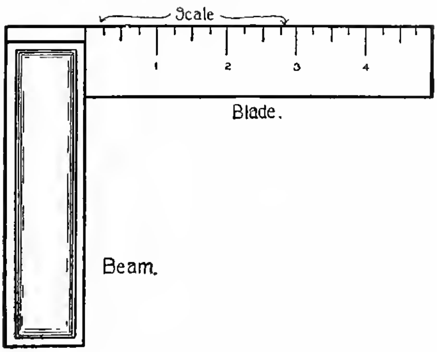


Fig. 27—Try Square

Test work often.

entire length of the piece. Sight across the face from end to end, to make sure the face is straight. If the piece is short it may be tested with a straight-edge, as in Fig. 29. The long blade of the carpenter's square is a good

Carpenter's square as straight-edge.

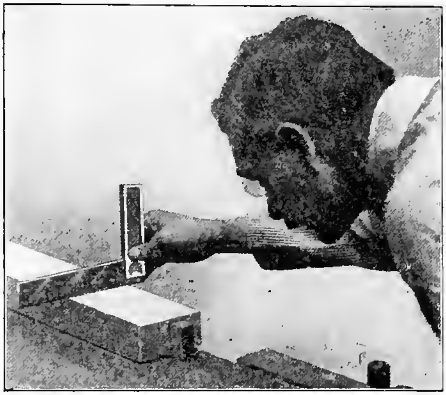


Fig. 28—Try Square Used as Straight-Edge

Fig. 29—Carpenter's Square Used as Straight-Edge

Mark working face.

straight-edge for such a test. When the face is finished it should be marked, for, as we have said, it is to be used as the base for all measurements. This face is now said to be *jointed* and may be marked No. 1, or with a corner mark spoken of later.

To Make a Face at Right Angles to Face No. 1

Try square used as a square.

Test the edges adjacent to No. 1 with the try square, as in Fig. 30, holding the beam of the square against face No. 1. Select the best edge, or the one most nearly square with No. 1. Sight over this edge to see if it is straight. If not, plane the high places until it is, then plane and test as in Fig. 30, until the blade of the square rests on the wood across the entire surface.

Squaring edge.

Tests should be made often, every two or three strokes of the plane, as was done in face No. 1, for on this edge the object is not to remove stock, but to make an edge

at right angles to the working face. In testing with the try square it should never be slid down the piece, for if the face of the beam is tipped at an angle the blade will be also, and will not give a true test. The square should be lifted free from the surface and set down carefully every inch or two. Use square carefully.

Fig. 30—Testing Edge for Squareness

Joint edge.

When the edge is made straight and at right angles to No. 1 it is called the *joint edge*, and may be marked No. 2. Or instead of marking these two faces No. 1 and No. 2, a good way to mark them, and one in common use, is shown in *a—b* (Fig. 31), the line *a—b* indicating the faces that have been jointed. Only these two faces should be marked, and these should *always* be marked.

Marking joint edge and working face.

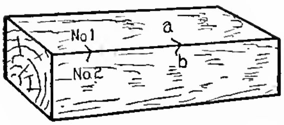


Fig. 31—Corner Marks Show Working Face and Joint Edge

We now have the working face and the joint edge and can proceed to face No. 3. The first step was to get a true plane; the second step to make a true plane at right angles to the first. The third step is to make a plane at right angles to the first and at a given distance from the second face. The best way to make the third step is to mark the exact dimensions by drawing a line on No. 1 at the given distance from No. 2. For making such a line parallel to the grain and parallel to a marked edge or face, the marking gauge, Fig. 32, is used.

Making third face.

The single lines on the beam of the gauge are called graduations, while the whole set of lines is called the scale, the same as in any rule. The marking point, or the spur (Fig. 32), should be sharpened to an obtuse wedge shape, as in *c* (Fig. 33). The spur thus sharpened will make a very shallow line, though one which is easily seen.

Parts of marking gauge.

Setting the gauge.

In setting the gauge it should not be assumed that the scale on the beam is correct, for when the spur is sharpened it is not likely that the point will come at the zero mark on the scale. We may, however, assume that the scale is nearly correct. The head may be set to the required dimension and the set screw turned lightly against the beam. Then with a separate scale, as in Fig. 34,

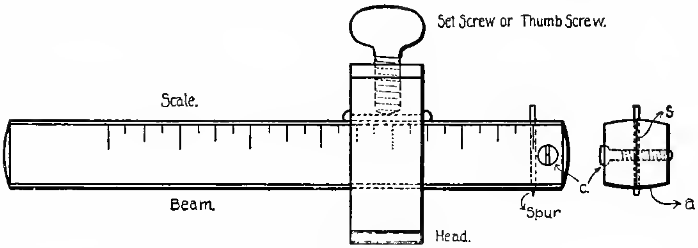


Fig. 32—Marking Gauge

Fig. 33—Method of Sharpening Spur for Marking Gauge

the measurement may be tested and the head brought to the proper dimension by a light tap on the bench. The set screw is then made tight and the measurement checked by measuring again to make sure that the head has remained in position. The screw (*c*) and the slot (*s*) (Fig. 32) are for clamping the spur and holding it in position as well as to allow it to be removed for sharpening.

Fig. 34—Setting the Gauge to Exact Dimensions

Keep head of gauge on a marked face.

In making a line with the gauge the head should always be held against a marked edge or face. The face of the beam from which the spur projects is made oval (*a*) (Fig. 32), and should always be placed in contact with the surface upon which

the line is to be made (Fig. 35). The hand should be placed on the gauge as in Fig. 36, the thumb being placed directly back of the spur. The oval face of the beam admits turning so that the spur may be made to cut a deep or a shallow line. When the line is made it should be exactly parallel to the joint edge, or face No. 2.

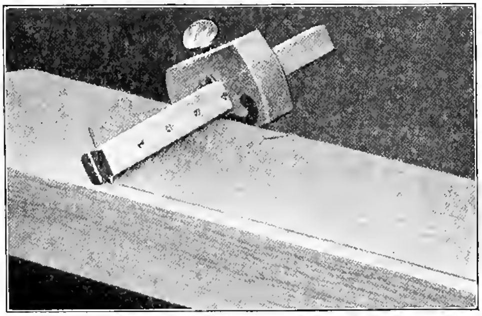


Fig. 35—Position of Gauge for Making a Line

Making line with gauge.

To test the line, place the head of the try square against face No. 2, or joint edge, as in Fig. 37, and slide it along the edge, keeping close watch of the gauge line and the corresponding graduation on the square. The line should be straight and uniform throughout the entire length of the piece. If the ends are to be planed to length it must be done before the third side is jointed. (See end planing at the end of chapter.)

Testing gauge line.

Fig. 36—Holding the Gauge for Making a Line

Fig. 37—Testing the Gauge Line with the Try Square

The above conditions all met, we can now plane the third face. If we follow the line on

Planing third surface.

face No. 1 the third edge will be straight, and if we square with face No. 1 we shall have filled all the required conditions.

Splitting the line.

In planing to a gauge line we should always plane to the centre of the line, for in setting the gauge (Fig. 34) the centre of the spur, or marking point, is placed in the centre of the required scale graduation, therefore the centre of the line will mark the required dimension. This is what the wood-worker calls splitting the line (Fig. 38).

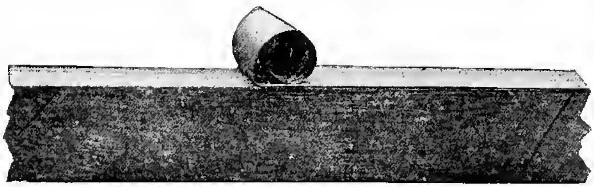


Fig. 38—Splitting the Line with Plane

Test work frequently.

If the line is made shallow the corner of the piece will be left in good condition. Frequent use should be made of the try square, as was done in making the joint edge. (See Fig. 30.) The last shaving should split the line and leave the third face square with the working face, or No. 1.

The fourth surface.

The fourth and last surface is made square with the joint edge (face No. 2) and at the required distance from No. 1, the working face. This will involve no new feature except that we can make a line on faces Nos. 2 and 3, which will do away with the necessity of using the square so much.

End Planing

If the ends of the piece are to be planed to an exact length, the end planing should generally be done before the third side is planed. End planing is not easy, however, and we shall learn in the succeeding chapters that in many cases it can be dispensed with altogether or left until later. The workman should use his own judgment, and he must know the purpose for which the piece is to be used.

To plane the ends of a piece of wood to exact dimensions we must first make careful measurements of the length and mark those meas-

urements with exact lines. To measure and mark those exact lines, we shall have to use the *rule*, the *knife*, and the *square*.

Rule, knife, and square

When making an exact measurement the rule or scale should be placed edgewise on the piece to be measured, as in Fig. 39, and never as in Fig. 39*a*, for in the latter case the scale lines will be so far from the face of the piece that the measurements cannot be located accurately with the knife point. The mark made by the knife point should be so small that a line drawn through it will entirely erase it. Note Fig. 39*b* and Fig. 39*c*. The knife should always be used for making careful measurements, for the pencil makes too large a mark. The knife used in making lines should be ground as in Fig. 39*d*. The point should be sharp but ground at an obtuse angle, as at *b* (Fig. 39*d*). A knife thus ground will make a positive shallow line. It will spread the fibres of the wood so that the centre of the line may be easily seen and worked to. The knife ground as in *c* (Fig. 39*d*), is so thin that it sinks too deep into the wood. The fibres are not spread apart, the line is not so easily seen as is the one made with the obtuse blade. The centre is not visible and is so far away from the visible part of the line, as *C* (Fig. 39*e*),

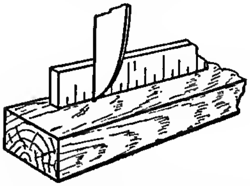


Fig. 39—Correct Way to Locate Point with Knife and Rule

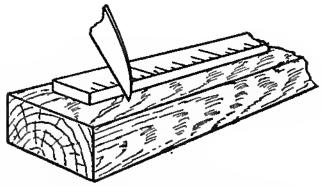


Fig. 39a—Incorrect Method of Locating Point with Knife and Rule

Locating measurement.

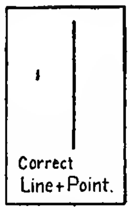


Fig. 39b—Correct Line and Point

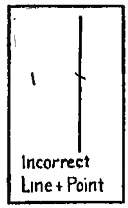


Fig. 39c—Incorrect Line and Point

Knife point for making lines.

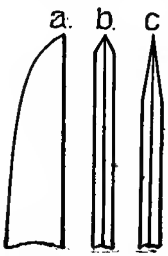


Fig. 39d—Knife Point for Making Lines

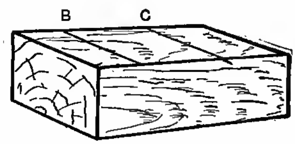


Fig. 39e—B, Correct Line; C, Incorrect Line

that it does not mark the required dimensions. From this it will be seen that the point of the knife for making lines is a very important thing in accurate wood-work.

Making line with knife and square.

With the measurements made and located by a small mark of the knife point and the knife properly ground for making a line, place the point of the knife in the mark, put the head of the try square

Fig. 39f—Putting Knife and Square in Position to Draw Line

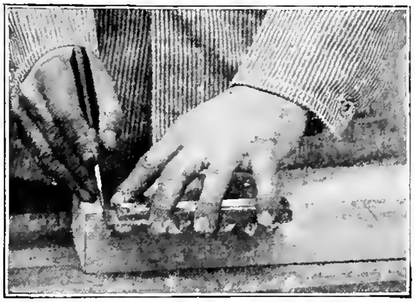


Fig. 39g—Knife and Square in Position for Drawing Line

Fig. 39h—Drawing the Line

on face No. 2, or the joint edge as in Fig. 39*f*, push the square up to the knife (Fig. 39*g*), and draw the line as in Fig. 39*h*. Turn the piece from you, place the point of the knife in the end of the line just drawn,

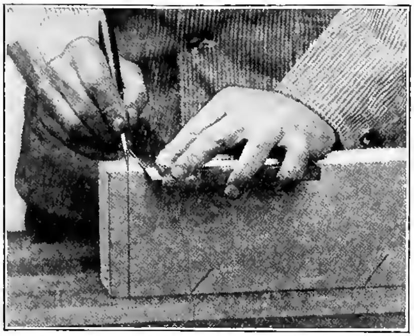


Fig. 39i—Putting Knife and Square in Position for Drawing Line on Edge

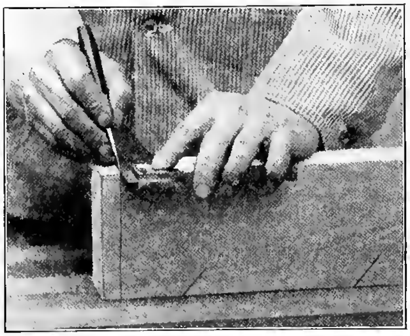


Fig. 39j—Knife and Square in Position for Drawing Line on Edge

put the head of the square on face No. 1, or the working face, Fig. 39*i*, push the square up to the knife as in Fig. 39*j*, and draw line across the joint edge.

When the piece is ready for squaring, the ends and third face will be marked, or laid out, as in Fig. 39*k*. It will, however, be best to saw close to the end line before planing. We must learn early that the saw is the best tool for removing large amounts of material. If the end sawing is done carefully with a saw that has fine teeth it will take but a few strokes of the plane to bring the end to the line and make it smooth. Before planing cut off or bevel the corner as at *a* (Fig. 39*l*). The object of the bevel is to prevent splitting the wood when the plane cuts off the edge of the piece.

Piece laid out for end planing.

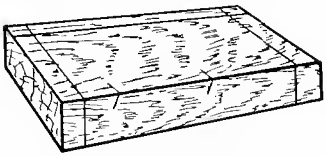


Fig. 39k—Piece Lined for End Planing

The *Block* plane, made especially for end planing is shown on page 8 (Fig. 7*a*), though a good, sharp, smooth plane may be used to advantage especially on hard wood and large ends. The try square should always be used to test the

Block plane.

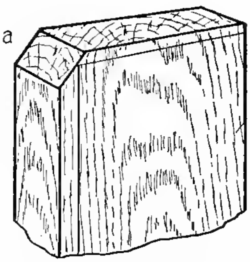


Fig. 39l—Corner Bevelled for End Planing

Planing against block.

squareness of the end as it was in testing the joint edge (page 17) (Fig. 30). The squaring should be done both from the joint edge and the working face. If there is not enough stock to make a bevel large enough to prevent the edge from splitting, a separate piece may be clamped in the vise back of the edge as in Fig. 39*m*, and the planing be done across both pieces. Or the planing may be done from both edges toward the centre.

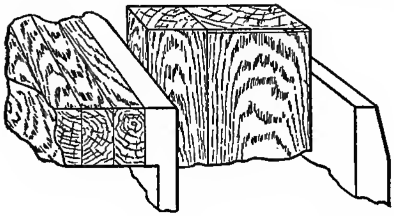


Fig. 39m—Block Back of Piece in Vise for End Planing

SUMMARY

The first piece finished, we have learned the following:

Elements of wood-work and their order—Problem, Tool, Material.
How to write an order for a bill of lumber.
General facts about the saw.
How to tell the crosscut saw from the rip saw.
Kinds of planes—some of their uses—the names of the parts—how to care for and adjust them.
Measuring from a single starting-point.
Joint edge and working face.
Planing a surface.
Use of try square as a straight-edge and as a square.
Carpenter's gauge—the parts and how to use it.
Planing a piece of wood to given dimensions.
The knife and square for making lines across the grain.

We are now ready for more advanced work.

CHAPTER II

THE LAP JOINT, WITH SEQUENCE OF DRAWINGS AND TOOLS NECESSARY FOR QUICK, ACCURATE PRODUCTION

Material Required: Pine or poplar, 2 pieces $1\frac{1}{2}'' \times 1\frac{3}{4}'' \times 5''$.

Written statement of problem not sufficient.

One-half the thickness of the first piece is to be cut out $1\frac{3}{4}''$ from the end, back. The centre of the second piece is to be cut out so as to receive the end remaining on the first piece after cutting out one-half the thickness of the material, as ordered above. The two pieces must fit perfectly, two sides of the first being level or flush with two sides of the second. The small end of the first must be even or flush with one edge of the second. The other end of the first must extend back on the opposite side $3\frac{1}{4}''$. When completed the joint resembles the capital letter "T."

The above is one of the most simple, as well as the most common ways of joining two pieces of wood; but if one were not familiar with such a joint it is doubtful if the statement of the problem would be sufficient to give a clear idea of what is wanted; though the attempt has been made to state the problem as clearly as possible in words alone. For such a simple problem, a photograph or a perspective drawing, as in Fig. 40, will assist very much in giving an idea of the general shape. Or we might make use of illustrated description, as was

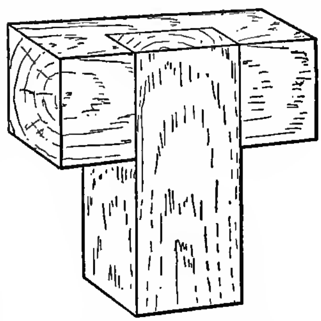


Fig. 40—Picture or Perspective Drawing of Lap Joint

Illustrated description not sufficient statement of problem

done in giving the names of the parts of the plane, Figs. 24 and 25, page 14. Even for a single joint, these methods are cumbersome, and it is obvious that they are limited to very simple problems.

Photograph not sufficient statement of problem.

If we had an article of wood-work involving many joints and pieces, as in Fig. 40*a*, either method would be altogether inadequate, for, while we can see at a glance the shape of the object and the various parts, the exact size and the way of uniting them cannot be shown, for many of the most important details are concealed from view. This being the case, it will be necessary for us to have a more definite as well as a general way of stating our problems.

Fig. 40a—A Photograph Does Not Give Details of Construction

Mechanical drawing the language of the mechanic.

If we go to the factory or workshop we shall find a picture and word language in general use which, though simple in principle, is capable of being used to express the most complicated problem of construction. Some knowledge of this language is necessary for the designer or the workman who would go beyond the first step in design or construction. This language is Mechanical Drawing.

Our problem for the next few pages will be to learn the fundamental principles of this language, in order to state the present problem correctly and definitely.

Mechanical Drawing

The mechanical drawing is distinguished from the photograph or perspective drawing, in that it does not give the whole object in one view or picture. It must have two or more views. For example Fig. 41 is the perspective, or picture, of the same object which is represented by a mechanical drawing in Fig. 41*a*. The difference between these two methods of expression is that in Fig. 41 the object is looked at from one point, as in Fig. 42. But in Fig. 41*a* the object is viewed not from one point but from many points, and always in parallel lines, as in the direction of the arrows (*E*) (Fig. 43). The object or the eye is moved in such a way that each point is viewed by itself. From the positions *E*, *E*, *E*, etc., only the elements of side (*A*) will be seen. From *F*, *F*, *F*, etc., we get the elements of *B*. The positions *E*, *F*, *G*, as well as any other positions from which the object may be viewed, are always at right angles to each other.

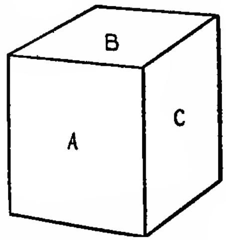


Fig. 41—Perspective Drawing or Picture of Block

Difference between mechanical and perspective drawing.

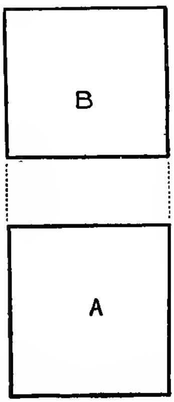


Fig. 41a—Mechanical Drawing of Block Shown in Fig. 41

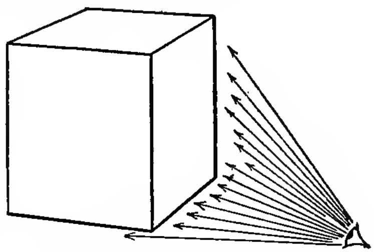


Fig. 42—Block Viewed from One Point

Any one can see that Fig. 41 represents an object having three dimensions. It is not so easy to see that Fig. 41*a* represents the same object, or that it gives more exact information than does Fig. 41. In Fig. 41*a* the lines are given in their exact length and the surfaces in their exact sizes; while in Fig. 41 some of the lines and surfaces are viewed at an angle and appear shortened.

The method of viewing the object, and of placing and interpreting the different views, are the difficult problems of mechanical drawing, and in fact are the basis of the whole subject.

The problem of mechanical drawing.

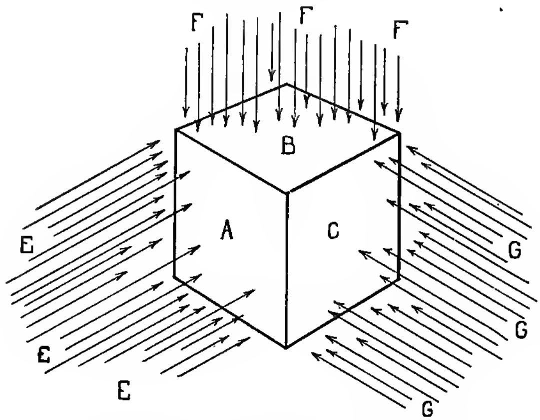


Fig. 43—Block Viewed from Many Points and Always in Parallel Lines

Our problem now is to understand the three fundamental parts of mechanical drawing:

(*A*) The view points.

(*B*) Placing of the views.

(*C*) Interpreting the meaning of each view.

Plan and elevation.

If an object stands on its natural base, as the cylinder in Fig. 44, the view we get from the direction of the arrows (*C*) will be the *Plan*, and the view from the direction (*D*) will be the *Elevation*.

If we consider a cube, as in Fig. 43, where there is no natural base, any side may be taken as a base and the views made accordingly.

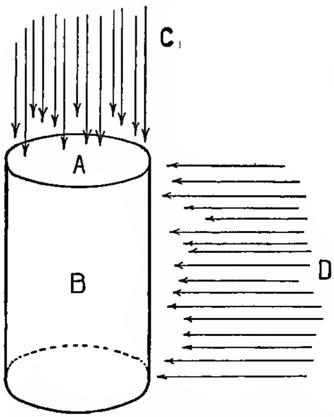


Fig. 44—Viewing Cylinder to Get Plan and Elevation

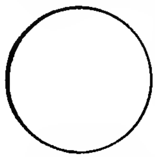


Fig. 45—Cylinder Viewed from the Top

The plan and the elevation are always at right angles to each other and represent the horizontal and the vertical views respectively. What we really see in the direction of the arrows (*C*) (Fig. 44) is a circle, as in Fig. 45. From

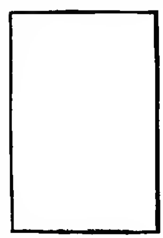


Fig. 46—Cylinder Viewed from the Side

Placing the plan and elevation in proper relations.

the direction of the arrows (D) we see an object as represented in Fig. 46. As Fig. 45 and Fig. 46 now stand there is no relation between them, and unless the mechanic has followed all that has been said about the cylinder the two views thus placed would not suggest one to him. If we place the views as in Fig. 47, the plan directly above the elevation and joined to it by dotted lines, and make the agreement that we will always place the views of a drawing in the same relation, the mechanic will see at a glance that the two views represent a cylinder.

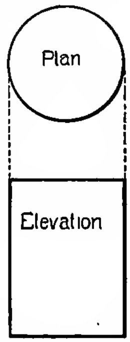


Fig. 47—Plan and Elevation of Cylinder in Proper Relation to Each Other

Fig. 48, Fig. 49, and Fig. 50 are the pictures, or perspective drawings, of the objects which are represented mechanically in Fig. 48*a*, Fig. 49*a*, and Fig. 50*a*, respectively.

Similarity of elevations.

We note as these three objects are represented here that the elevations are the same, while the plan of each is different. If we turn Fig. 48 in either direction, but leave it upon the same base, neither the plan nor the elevation will change, for the object is symmetrical. If we turn Fig. 49 upon its base to the position of Fig. 51, the mechanical drawing will be as in Fig. 51*a*. If turned as in Fig. 52, the drawing will be as in Fig. 52*a*. If Fig. 50 is turned as in Fig. 53, the mechanical drawing will be as in Fig. 53*a*.

Change of view point.

We see from this that while the plan has been turned at an angle it is the same as before and has no added lines, while the elevation

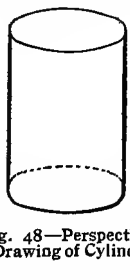


Fig. 48—Perspective Drawing of Cylinder

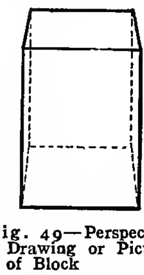


Fig. 49—Perspective Drawing or Picture of Block

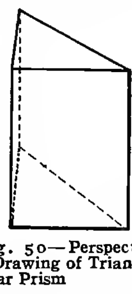


Fig. 50—Perspective Drawing of Triangular Prism

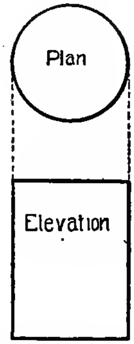


Fig. 48a—Mechanical Drawing of Cylinder

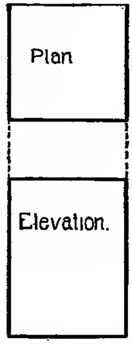


Fig. 49a—Mechanical Drawing of Block

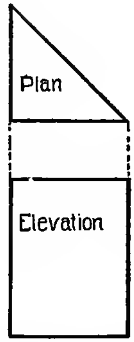


Fig. 50a—Mechanical Drawing of Triangular Prism

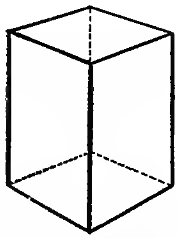


Fig. 51—Picture of Fig. 49 in Different Position

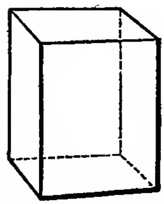


Fig. 52—Picture of Fig. 49 in Changed Position

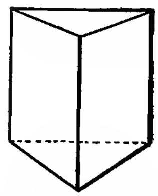


Fig. 53—Picture of Fig. 50 in Changed Position

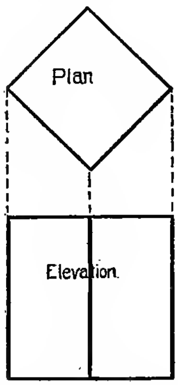


Fig. 51a—Mechanical Drawing of Fig. 49 in Position of Fig. 51

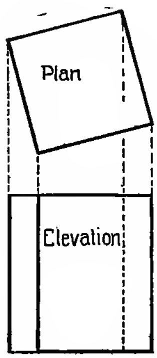


Fig. 52a—Mechanical Drawing of Fig. 49 in Position of Fig. 52

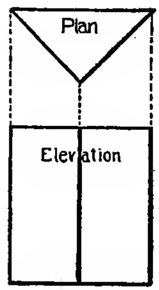


Fig. 53a—Mechanical Drawing of Fig. 50 in Position of Fig. 53

has changed. It is, therefore, evident that there may be a number of elevations of the same object.

In practice, the first view made is the one which will give the most information; that is, the object is viewed at right angles to the most important surface. The first view.

Placing the Different Views

In Fig. 54 there are two end elevations (C) and (D); two side elevations (A) and (F), and a top and bottom plan (B, G). If we make the plan (B) (Fig. 54a), then the front side elevation (A) will be below and the back elevation (F) will be above, the right end elevation will be (C) to the right, and the left end elevation will be (D) to the left.

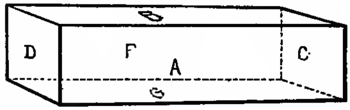


Fig. 54—Picture of Perspective Drawing of a Rectangular Block

In other words, the position of the view tells which part of the object is represented by it. The right end to the right, the left end to the left, the front elevation below the plan, and the rear elevation above the plan. These facts are fundamental and should always be remembered.

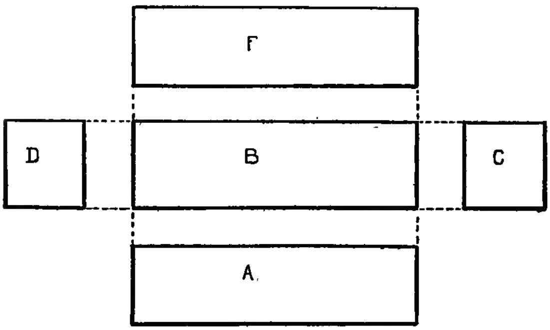


Fig. 54a—Mechanical Drawing Showing Different Views of Rectangular Block Shown in Fig. 54

Showing Invisible Lines

Fig. 55 is a block with a round hole in it. From the end such a hole would be visible, but from the side it is not. The view of the block from the end has told us the hole is there, and Dotted lines.

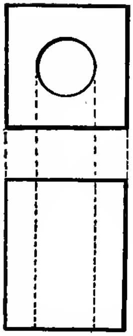


Fig. 55—Dotted Lines in Elevation Show Where Hole Would Be if We Could See It

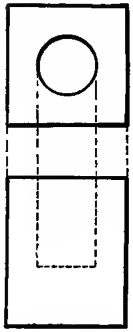


Fig. 56—Dotted Lines Locate Hole Which Does Not Pass Entirely Through Piece

while the block is not transparent, we can imagine it is and represent the invisible sides of the hole with dotted lines, as in Fig. 55. Fig. 56 shows a block in which the hole does not pass entirely through. Lines which are invisible from any view point are made dotted in that view.

The object in Fig. 57 is represented mechanically in Fig. 57*a*.

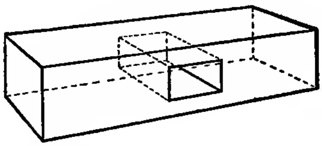


Fig. 57—Perspective Drawing of Rectangular Block with a Rectangular Hole

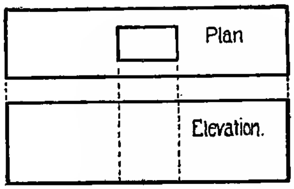


Fig. 57a—Mechanical Drawing of Fig. 57

The Number of Views Necessary

In Fig. 54*a* *B* gives the length and width, *A* and *F* the length and thickness, and *C* and *D* the width and thickness. Any two of the views would give the necessary three dimensions. In practice, no more views are made than are necessary. There must always be two views, for a single view can give but two dimensions. If either end, face, or side is different from the corresponding end, face, or side, then more than two views may be necessary to avoid confusion.

Two views always necessary.

Scale of Drawings

In all of the above consideration of mechanical drawing it is assumed that the drawing is the size of the object. It is evident that the usefulness of such drawings will be limited. We therefore make them to suit our convenience, as, for example, one-half size, one-quarter size, etc. Or, if the object is small, the drawing may be larger than the object itself. The size of the drawing in relation to the object is called the *scale*. We can choose any scale we like, but having once chosen, the same scale must be followed throughout. The scale may be written in two ways, either by writing "Scale half size," "Scale quarter size," etc., or 6″=1′ (read six inches equals one foot), 4″=1′ (four inches equals one foot), etc. The scale is only for the use of the draftsman. The mechanic should *never measure a drawing to get a dimension;* but use the dimension given. No drawing is complete which is not accompanied with full dimensions carefully and plainly written.

Writing scale on drawings.

Dimensions on Mechanical Drawings

The dimensions on a mechanical drawing always give the full size of the object, regardless of the scale.

Writing dimensions on drawings.

In order to give the dimensions a positive beginning and ending, the figures giving the dimensions are placed in the centre of a dash line, as in Fig. 58 and Fig. 58*a*. At the ends of the line are placed arrow heads, (x, y) (Fig. 58*a*), the points of which mark the *exact* limits of the dimensions called for by the figure in the line. The dimension

Use of the arrow heads.

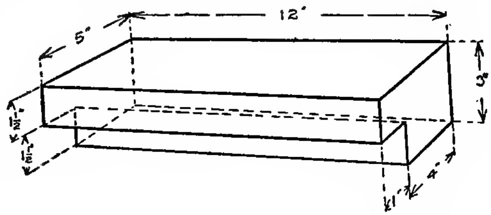


Fig. 58—Dimensions Given on the Picture or Perspective

line should always be parallel to the line or opening, the dimension of which is given by the figure at its centre.

To avoid confusion of lines.

In order to avoid confusion with other lines, the dimension lines should be placed outside of the drawing wherever it is possible to do so. If outside of the drawing, dotted lines should lead out to the points of the arrow heads as at x, y (Fig. 58a).

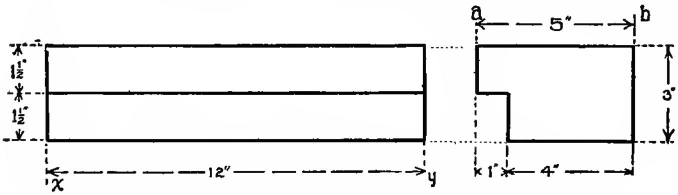


Fig. 58a—Mechanical Drawing of Fig. 58, with Complete Dimensions

Correct and incorrect dimension lines.

A dimension line should never be a continuation of any line in the body of the drawing, as at a, b (Fig. 59), but should be placed either up within the drawing, as at a^1, b^1 (Fig. 59a), or what is still better, outside of the drawing, as at a^2, b^2 (Fig. 59a).

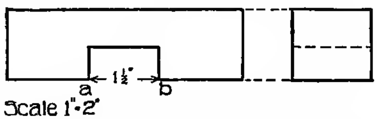


Fig. 59—Incorrect Placing of Dimension Line

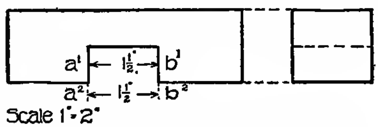


Fig. 59a—Correct Placing of Dimension Line

The sum of a series of dimensions.

Several dimensions may be placed in a series, as in Fig. 59b. The mechanic should never get dimensions by measuring the drawing, and if a series of dimensions are given, as in Fig. 59b, the sum of the series must be given as shown. Figures must be made plainly and never less than one-eighth of an inch in size.

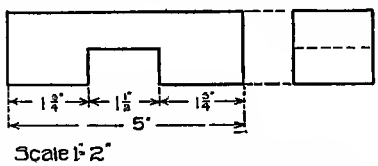


Fig. 59b—The Sum of a Series of Dimensions Must Be Given

Writing of fractions.

Fractions must always be written with a straight dividing line, as $\frac{15}{16}$, never with a slanting line as ${}^{15}/_{16}$. The latter fraction may be read in two ways, $1\frac{5}{16}$ or $\frac{15}{16}$, with equal assurance that either is correct. This would lead to many serious mistakes.

A whole number and a fraction should be written as $1\frac{5}{16}$, so that the dividing line comes opposite the centre of the whole number. The figures in a mechanical drawing should be written perpendicular, as $\frac{3}{4}$, or horizontal to the right, as $\frac{3}{4}$.

Write all symbols carefully.

In writing the marks that mean inches and feet, or any other symbol, care should be taken to put them in their proper places and to make them of proper size; for example, $1\frac{1}{2}''$, or $1\frac{1}{8}''$, or $11'$, or $10'$. If they are written carelessly, as $1\frac{1}{2}$||, or 11||, or $10_{||}$, we should not know what was wanted, for the symbol might be taken for a figure.

Symbols should always be placed in the right position with reference to the figures with which they go. If the symbol for inches in the fraction $\frac{7}{8}''$ were written $\frac{7}{8}_{''}$ the two small lines would have no more significance than would a decimal point placed at *a* in Fig. 60.

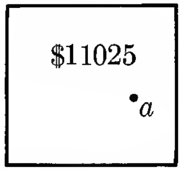


Fig. 60 — Incorrect Position of Decimal Points

In short, every symbol, figure, or part of a mechanical drawing says but one thing, and, if correct, cannot be made to say more or less than the idea it is meant to convey.

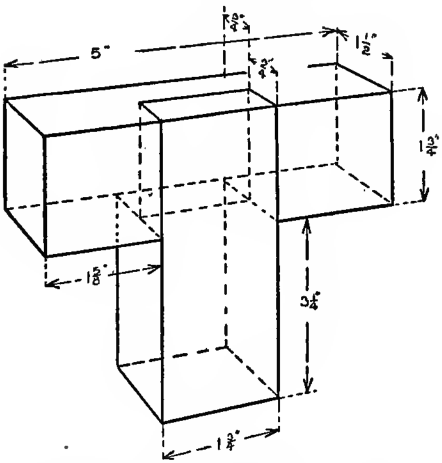


Fig. 61—Perspective Drawing of Lap Joint with Dimensions

The Problem of the Lap Joint Stated

We are now able to state our problem and proceed at once with the more simple forms of construction. Figs. 61 and 61*a* will be readily recognized as the perspective and mechanical drawing, respectively, of the lap joint that we have attempted to order in other ways on page 25. Fig. 61*a* is all the statement of the problem that we

need. In it we have given every dimension and the kind of material to be used. We note that the joint is made of two pieces of poplar each $1\frac{1}{2}'' \times 1\frac{3}{4}'' \times 5''$. If we order our stock, or material, all in one piece and make it to the required thickness and width before we cut it in two, we shall be able to make both pieces with but one handling of the tools. As in ordering the first piece we will allow one-eighth of an inch in thickness and width, and one-half of an inch in length for finishing. The mill order for the stock will be: Poplar (or Pine) —1 piece—$1\frac{5}{8}'' \times 1\frac{7}{8}'' \times 10\frac{1}{2}''$.

Combine parts for planing.

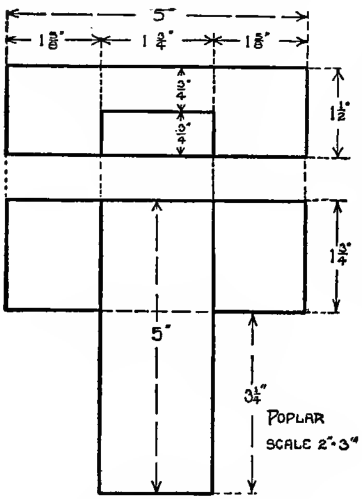


Fig. 61a—Mechanical Drawing of Lap Joint

How to Lay Out and Make a Lap Joint

The first step, planing the stock to the required dimensions, is merely a review of the first problem, pages 1 to 20, inclusive. The end planing may be omitted and the piece left one-half an inch too long. The reason for this omission will appear as the work progresses.

The problem now is, how shall we proceed to make Part 1 and Part 2 (Fig. 61*b*), from a piece as shown in No. 1 (Fig. 61*c*), with the least amount of work, and at the same time be sure that we shall have a well-made joint when each part is finished?

General problem.

This is a general problem and we may omit the dimensions because the method of laying out the joint will be the same for all dimensions.

Measuring line.

The ends of the piece are rough and uneven, as they were left by the saw. It will therefore not be possible to make accurate measurements from the ends. In such cases we make a line near

the end from which all measurements are made, as $a—a^2$ (No. 2, Fig. 61*c*). This we call the measuring line.

Read carefully the use of the Rule Knife and Try Square for making lines (pages 22 and 23) (Figs. 39*f* to 39*j*, inclusive).

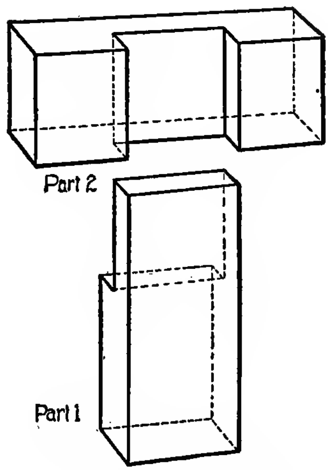


Fig. 61b—Perspective Drawing of the Parts of the Lap Joint

To lay out part No. 1.

To lay out Part 1 (Fig. 61*b*), from $a—a^2$ (No. 2, Fig. 61*c*). Measure the required distance and draw to $b—b^2$ (No. 3).

With the beam of the square on face No. 1, draw $b—c$ and $b^2—c^2$ on face No. 2 and face opposite (see No. 4, Fig. 61*c*). With the gauge set for the required thickness and the head of the gauge on face No. 1, draw $c—d$ (No. 5, Fig. 61*c*) to the end, $d—d^2$ across the end, and $d^2—c^2$ on the face opposite No. 2.

This gives lines bounding the piece to be cut out of Part No. 1 (Fig. 61*b*). To locate the length of part No. 1, measure the required distance from $a—a^2$ (No. 6, Fig. 61*c*), and square the lines $e—f$, $f—g$, $g—h$, and $h—e$ around the piece.

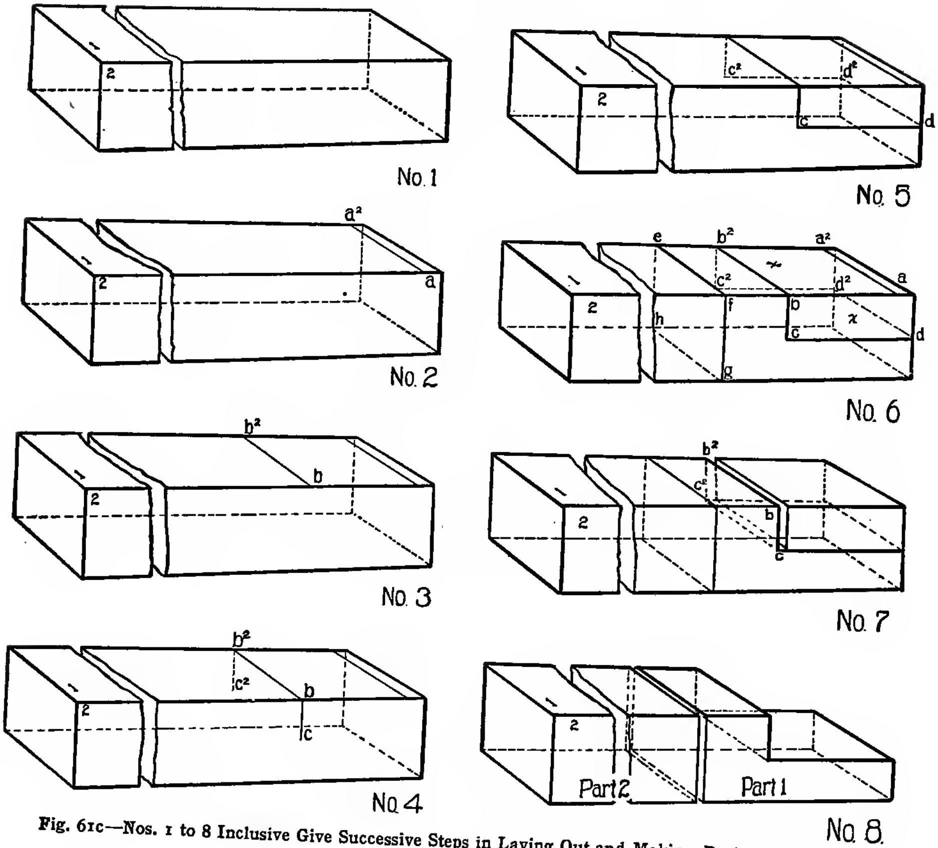


Fig. 61c—Nos. 1 to 8 Inclusive Give Successive Steps in Laying Out and Making Part 1 of Lap Joint

To Square Around a Piece

In squaring around a piece, as well as in making all other lines where the blade of the square is used as a straight-edge, *the beam must be held against one of the two marked faces,* that is, face No. 1 or No. 2.

The line *e—f* (No. 6, Fig. 61*c*) is drawn the same as the other lines across the grain. To draw *f—g* turn the piece from you, place the knife in the end of the line *e—f,* and proceed to draw the line as

in Figs. 39*i* and 39*j*, page 23. To draw *g—h*, turn the piece from you and proceed as before, except that the head of the square must be against face No. 2, as in Fig. 62. Draw the line *h—e*. With the beam of the square on face No. 1, *h—e* and *f—e* must exactly meet at the point *e;* if not, a mistake has been made. The work should be checked, the mistake found and corrected.

Check accuracy of all lines.

Fig. 62—Drawing Line on Fourth Face of Piece

The accuracy of all work depends upon the accuracy of the lines.

We are now ready to remove the part *x* (No. 6, Fig. 61*c*). To do this we shall need two new tools, the bench hook (Fig 63), and the back saw (Fig. 65). The bench hook is used to hook on the edge of the bench, as in Fig. 64. The end

Bench hook.

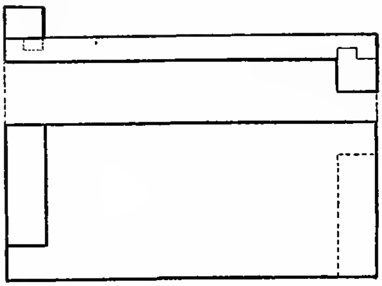


Fig. 63—Mechanial Drawing of Bench Hook

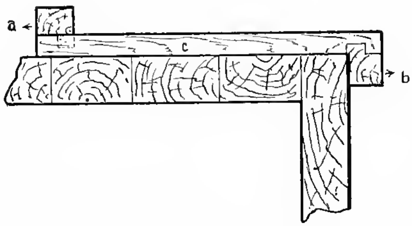


Fig. 64—Bench Hook on Edge of Bench

piece (*b*) holds the hook from slipping on the bench. The piece (*a*) is to push against while sawing or chiselling, and the base (*c*) prevents the top of the bench from being sawed or cut by edge tools.

The back saw (Fig. 65) is a saw with a thin blade and small teeth, made for accurate smooth sawing. The teeth are shaped

Back saw.

nearly like those of the crosscut saw (Fig. 4, page 6). A slight change is made in their shape, so that the saw will cut with the grain as well as across it.

The blade of this saw is so thin that it is not stiff enough to stand being pushed into the wood For this reason the stiffening piece (*B*) is placed on the back. The saw gets its name from this back piece.

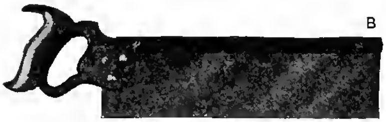


Fig. 65—Back Saw

With the above knowledge of the bench hook and back saw, we can proceed to cut out *x* (No. 6, Fig. 61*c*).

Starting the saw cut.

Place the piece on the bench hook, as in Fig. 66. Place the hand and saw on the piece, as in Fig. 66*a*. Hold the thumb against the blade until the cut is well started. The first stroke of the saw should be back against the teeth and toward the body of the piece. This backward stroke of the saw is to prevent splitting at the edge where the fibre would have no support if the saw were pushed forward. Keep the saw in a slanting position until the cut has

Fig. 66—Piece Placed on Bench Hook Ready for Sawing

Fig. 66a—Hand and Saw in Psition for Starting Saw Cut

reached the opposite corner (Fig. 66*b*). Saw on the lines b—c and b^2—c^2 to c and c^2 (No. 7, Fig. 61*c*), so as to leave a square shoulder. If care has been taken to make a line with the knife ground as directed in Fig. 39*d* (page 21) it will be easy to split the line, *leaving one-half of the line on the shoulder we wish to keep.*

Splitting the line with the saw.

This last statement is very important, for if the cut is made as directed the face of the shoulder will not require any further finishing.

There are two ways of cutting to the lines c—d, d—d^2, and d^2—c^2. If the wood is soft and straight grained the stock may be split out with a chisel, as in Fig. 67. If we are working in hard or cross-grained wood, it is much better to saw out the stock, as in Fig. 67*a*. To split out the stock will require the use of two new tools, the chisel and the mallet. The mallet and its use will be considered in the next chapter.

The Chisel

The chisel is ground and oil-stoned exactly as the plane bit (Figs. 16, 17, 18, 19, and 20, pages 12 and 13). To test the sharpness of the chisel, put a piece of soft wood in the vise and cut the corner across the grain. If the cut is smooth the chisel is sharp. If the fibres are pushed together, making the surface of the cut rough, the chisel should be sharpened.

Sharpening the chisel.

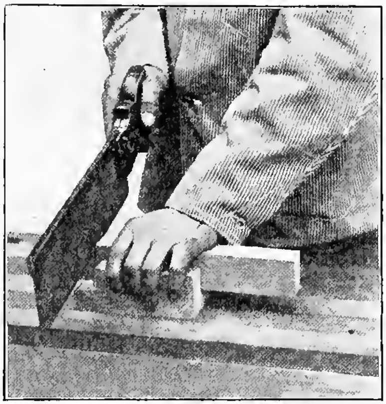


Fig. 66b—Cut Started. Position of Hand on Piece Changed

The size of the chisel is designated by the width of the cutting edge, as $\frac{1}{8}''$, $\frac{1}{4}''$, $\frac{3}{8}''$, etc., ranging by eighths up to one inch and in quarter inches from one to two inches.

Size of chisels.

Bevelling to lines.

If the stock is to be chiselled out, cut out all but about one-sixteenth of an inch of it, then bevel both edges to the centre of the lines, leaving the centre of the piece high, as in Fig. 67*b*. Pare down the centre, as

Fig. 67—Splitting Out Stock with Chisel

in Fig. 67*c*, and test the face, or cheek, of the chiselled cut with the square, as in Fig. 67*d*. The face, or cheek, of the piece should be even with the centre of the lines across the entire face, and should be square with the marked face.

Fig. 67a—Sawing Out Stock

Making a Paring Cut with a Chisel

Fig. 67*b* and Fig. 67*c* both show the method of holding the chisel when it is desired to make a careful cut. The handle of the chisel is gripped with one hand. The thumb of the other hand is placed on top of the blade and the forefinger below resting against the piece. The chisel is worked as a lever with the thumb and forefinger as a fulcrum. This gives the workman perfect control of the cutting edge of the chisel and is called the *Paring Cut*. If the stock is sawed out, as in Fig. 67*a*, the cheek should be tested with the square, as in Fig. 67*d*, and merely the rough fibres pared off with the chisel.

Sawing out stock.

Part 1 may now be cut from Part 2 (No. 8 of Fig. 61*c*). In this case half the line should be left on Part 1, as that is the permanent end we are cutting.

To lay out part No. 2.

To lay out Part No. 2, turn the piece so that the face opposite Face No. 1 is up (No. 1, Fig. 68). If the end is not square, a measuring line (i—i^2) should be made, as was a—a^2, Part 1, page 38, Fig. 61*c*. From the measuring line (i—i^2) measure to the required distance and make line k—k^2 with the square, as the lines were drawn in Part 1, No. 3, Fig. 68. Place Part No. 1 on Part No. 2 so that the shoulder on No. 1 comes exactly to the centre of line k—k^2 (see No. 4, Fig. 68), and draw line m—m^2 (No. 5, Fig. 68), using the edge of Part No. 1 as a square. This method of locating a line is called *the method of superposition.*

Fig. 67b—Bevelling Edge to Line

Fig. 67c—Paring Centre Down to Side Lines

Laying out by method of superposition.

Fig. 67d—Testing Surface of Chisel Cut with Try Square

With the head of the square on Face No. 1 draw the lines k—o, k^2—o^2 and m—n, m^2—n^2 half-way across Face No. 2 and the face opposite. With the head of the gauge on Face No. 1, and with it *set exactly,* as it was in making the lines *c, d,* etc. (No. 5. Fig. 61*c*), draw

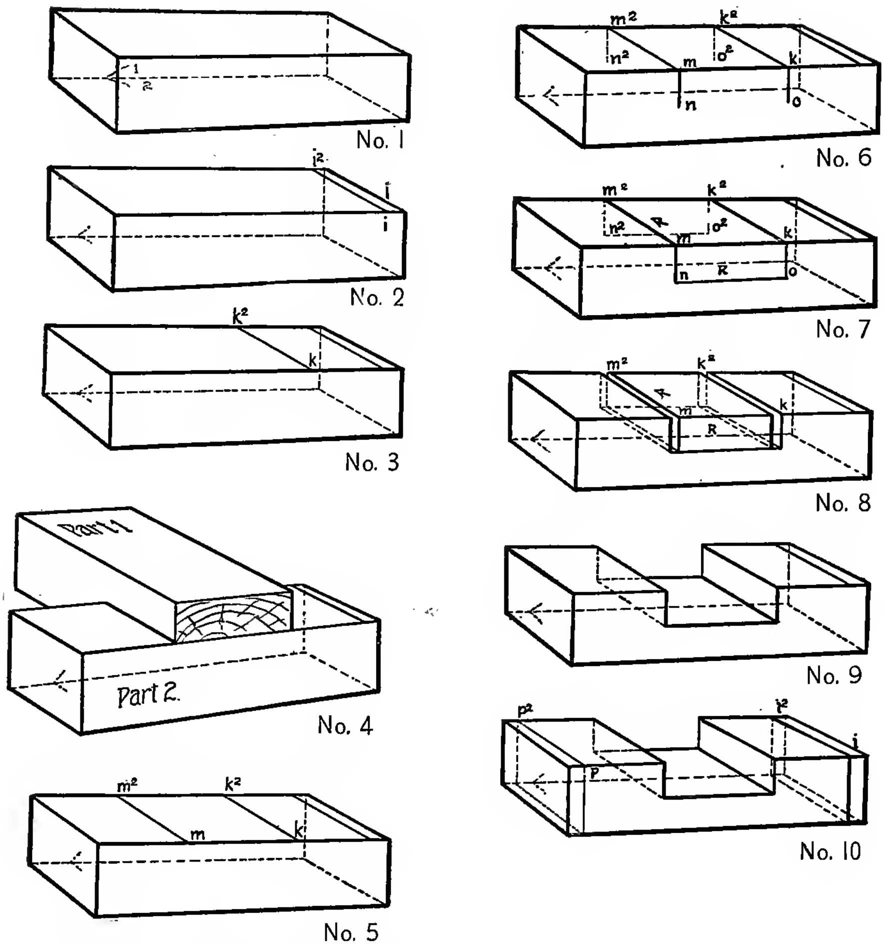


Fig. 68—Nos. 1 to 10, Inclusive, Fig. 68 Show the Successive Steps in Making Part II of Lap Joint

the lines n—o and n^2—o^2 (No. 7, Fig. 68). This gives us the boundary for the piece R to be cut out of Part 2.

To remove R (No. 7, Fig. 68), saw to the lines k—k^2, etc., and m—m^2, etc. (as in No. 8, Fig. 68), just as we did to shoulder line b—b^2, etc.

(pages 40 and 41, Figs. 66, 66*a*, and 66*b*), being very careful to leave one-half of each line on the body of the piece. Read carefully the rule for sawing to the line, page 41.

R is cut out with the chisel, as in Fig. 68*a*, by turning the stock in the vise and chiselling to the centre from each side. Bevel to the lines and leave the centre high, as in Fig. 68*b*. Pare centre level with lines and test with the try square, as in Fig. 68*c*. The head of a square must be on a marked face. Cut the ends to length and Part No. 2 is finished. Now, if we place the two parts end to end, so that the working faces are adjacent, as in Fig. 69, we note at once that cuts are made from the opposite sides. The reason for this will be evident if we note how both were laid out. In drawing the lines *c*, *d*, etc., and the lines *n*, *o*, etc., the head of the gauge was always on Face No. 1 and the gauge remained at the same setting. That is, the part cut out of Face No. 1 was measured exactly the same as the part left, when the piece was cut from the opposite face.

Fig. 68a—Removing Stock from Part II of Lap Joint

Chiselling out mortise in part No. 2.

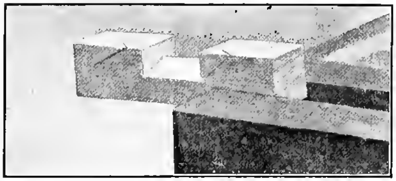


Fig. 68b—Cut Pared to Line Centre High

Fig. 68c—Testing Chisel Cut with Try Square

Reason for cutting out the stock on opposite faces

Now, if we put Part 1 and Part 2 together, as in Fig. 69*a*, the shoulder on Part No. 1 will fit against Face No. 2, and Face No. 1 on each piece will be adjacent and come even or flush with each other. If the work has been properly done, the parts will fit together closely, but one should be able to force them together with the hands. If we refer to No. 2, Fig. 61*c*, page 38, we shall see that in making the

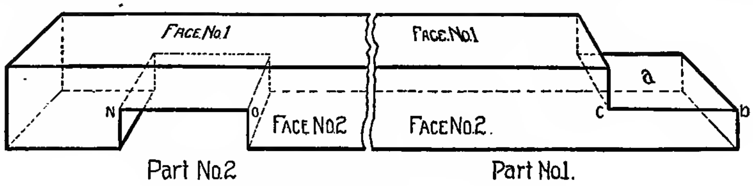


Fig. 69—Parts Nos. 1 and 2 in Original Position

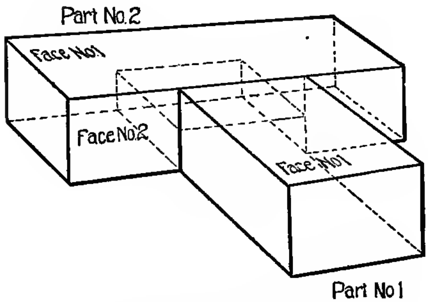


Fig. 69a—Parts of Lap Joint Put Together, Showing Relation of Faces

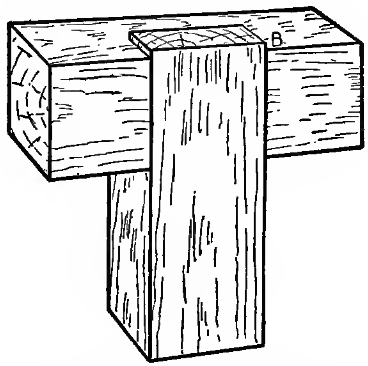


Fig. 69b—Lap Joint Parts Put Together, Showing Projecting End (B)

measuring line $a—a^2$ the end of Part 1 was made one-eighth of an inch longer than it should be. When put together the end of Part 1 will project beyond Part 2, as in Fig. 69*b*. This is a general practice in all mills. When opportunity offers, look at doors and window-sash as they come from the mill. One reason for leaving the end long is to make sure that the end when finished will come even or flush with the adjacent face. Another reason is that in chiselling or sawing the face (*a*, Fig. 69) the wood is likely to be more or less split at the end.

Reasons for leaving a long end on part No. 1.

Still another is that it is much easier to square the end to the required length when it is supported between the shoulders of the other piece. To remove the projecting end, bevel the edge (*B*, Fig. 69*b*) with the chisel, as in Fig. 69*c*, then with a small smooth plane or block plane held at an angle of about 45° to the face of the part, as in Fig. 69*d*, plane the end flush with the adjacent face. This will complete the joint.

To remove the projecting end of part No. 1.

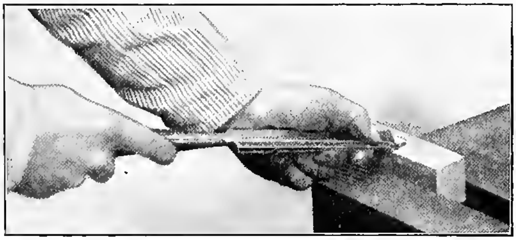


Fig. 69c—Bevelling Projecting End with Chisel

Various types and applications of this joint will be found on pages 58 and 59.

Fig. 69d—Planing Projecting End with Block Plane

SUMMARY

We have learned the following in Chapter II:

That the method of stating the problem used in Chapter I could be used only for simple problems.

The necessity of a better method of stating the problem.

The principles of mechanical drawing and some of the uses of such drawings.

Laying out and making a Lap Joint.

Bench Hook—How to use it.

Back Saw—How to use it.

Chisel—Some of its uses and how to care for it.

CHAPTER III

THE MORTISE AND TENON TYPE OF JOINT

THE example of this type of joint will be the Through Mortise and Tenon (Fig. 70).

Tenon and mortise defined.

The Tenon is the extension on Part No. 1 and the Mortise is the hole into which the Tenon fits (Part No. 2).

Mechanical statement of of problem.

The complete mechanical statement of the problem, that is, the mechanical drawing, is given in Fig. 70*a*. From the mechanical drawing we learn that the stock called for is Pine or Poplar: 2 pieces $1\frac{1}{2}'' \times 1\frac{3}{4}'' \times 5''$.

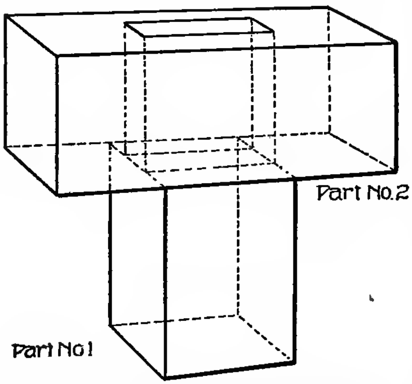


Fig. 70—Perspective Drawing of Through Mortise and Tenon Joint

Combination of parts in mill order.

Inasmuch as these two pieces are alike, and when in one piece are not too large to handle easily, we can save considerable time by ordering the stock in one piece and working both to thickness and width at the same time. Allowing one-eighth of an inch in both width and thickness and one inch in length for finishing, the order for the stock will be: Poplar or Pine: 1 piece $1\frac{5}{8}'' \times 1\frac{7}{8}'' \times 11''$. To make this piece to the required dimensions we have again a review of the first problem (pages 1 to 20, inclusive).

Jointing the stock.

After jointing the above piece, that is, after working it to the

required dimensions, it will still be to our advantage to lay out and cut the mortise and tenon before cutting the piece in two.

To Lay Out a Mortise and Tenon Joint

This is a general problem the same as the last and the dimensions may be omitted. It will be well at this point to read again the use of the laying-out tools in the last chapter.

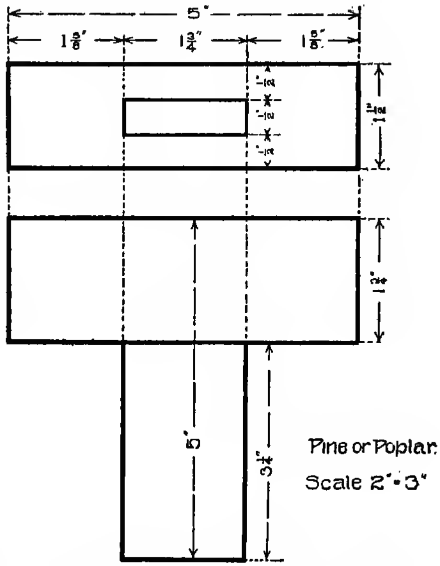


Fig. 70a—Mechanical Drawing of Through Mortise and Tenon Joint

Measuring line.

Draw measuring line a—a^2 (No. 1, Fig. 70*b*) about three-sixteenths of an inch from the end. From a—a^2 measure the required length of Part No. 1 and draw g—f, f—i, i—h, and h—g. For a cutting-off line allow one-quarter of an inch for sawing and squaring the ends, and draw the line k—j, j—m, m—l, l—k. These lines will enable us to exactly locate the mortise and tenon. Measure from a—a^2 the required dimension and draw the shoulder line for the tenon c—b, b—e, e—d, d—c (No. 2, Fig. 70*b*). Measure from k—l and locate the end lines for the mortise n—o and p—q. (No. 2, Fig. 70*b*.) These lines are to be made on Face No. 2 and the face opposite, but are not to be drawn beyond the limit of the mortise, because they would remain in the material and be visible in the finished piece. To locate n^2—o^2 on the face opposite No. 2, when drawing the line n—o make a small mark (v, No. 2, Fig. 70*b*) on the edge of the piece. Place the knife in this cut the same as if it

End lines.

Shoulder line for tenon,

To locate end lines of mortise.

were the end of a line, bring the square in position for making a line on Face No. 1, and make a small point at v^2; v^2 may also be used as the end of a line to locate n^2—o^2; p^2—q^2 may be located exactly opposite p—q in the same way.

To draw side lines for mortise and tenon.

Set the gauge to the required dimensions and with the head on

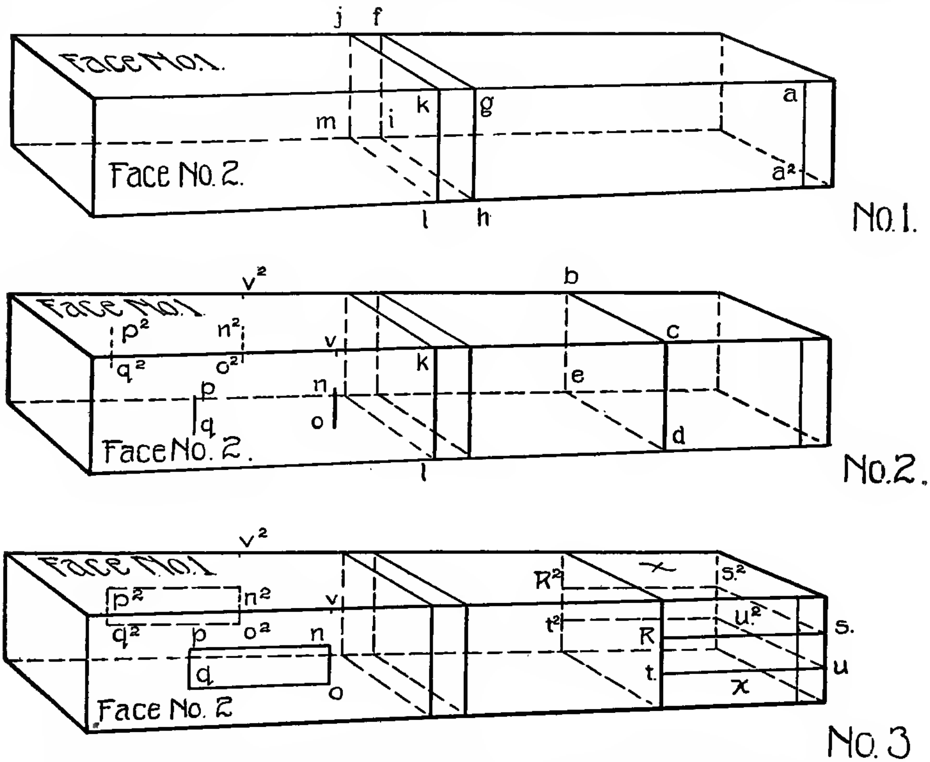


Fig. 70b—Nos. 1, 2, and 3, Fig. 70b, Show Successive Steps in Laying Out Through Mortise and Tenon Joint

Face No. 1 draw R—s (No. 3, Fig. 70*b*) to the end, s—s^2 across the end, s^2—R^2 back to the shoulder line on face opposite No. 2. Without changing the setting of the gauge connect the mortise lines at n—p and n^2—p^2 (No. 3, Fig. 70*b*), add the thickness of the tenon to the setting of

the gauge as it was used in marking the last lines, and with the head of the gauge on the same face draw $t—u$, $u—u^2$, $u^2—t^2$, the same as we did $R—s$, etc., and join $o—q$ and $o^2—q^2$.

We now have lines giving the exact boundaries of the mortise and tenon. Because of having made the lines $R—s$, etc., and $n—p$, etc., with one setting of the gauge, and $t—u$, etc., and $q—o$, etc., with another setting, but from the same face, we know that the thickness of the tenon and the width of the mortise are exactly the same.

Saw out $x—x$ (No. 3), using the back saw to cut with the grain as well as across it. No chiselling should be done on the shoulders and but very little on the faces of the tenon. The end should be bevelled as in Fig. 70*c*. The bevel allows the tenon to enter the mortise and prevents the end from catching in the sides as it is pushed into it. Removing stock from sides of tenon.

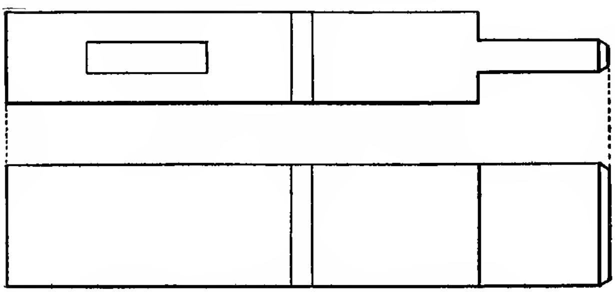


Fig. 70c—Mortise and Tenon Ready to Cut Apart

The next step is the only new operation—that is, to remove the stock from the mortise. There are two ways of removing the bulk of the stock. It may be bored out with a bit or it may be chiselled out. In the case in hand, where the wood is soft and the piece not large, the chisel is probably the best tool to use. Removing stock from mortise.

To Cut Out a Mortise with a Chisel

Choose a chisel at least one-sixteenth of an inch smaller than the width of the mortise to be cut. Be sure that the chisel is sharp. The mallet comes into use here again. The mallet is a round or square-shaped hammer made of hard, heavy wood (Fig. 70*d*), and is used to Choice of chisel. The mallet.

Reasons for using a mallet.

drive the chisel into the stock. The weight of the mallet imparts a great force to the chisel, even with a light blow, while a hard blow with a light carpenter's hammer nearly splinters the chisel handle and does not sink the chisel deep into the wood. Consequently the *carpenter's hammer is never used for driving a chisel.* The chisel should be started in at the centre of the mortise with a light cut, as at *a*, No. 1, Fig. 70*e*. The cut should be a little deeper with each stroke and brought up to about one-sixteenth of an inch of the end line of the mortise with the flat side of the chisel toward the line, as at *b*, No. 1, Fig. 70*e*. With the chisel, as at *d*, No. 2, drive it into the wood. The slanting position, as well as the bevel, will advance the chisel toward the part already cut. This raises the chip, as at *c*, No. 2,

Starting the chisel cut.

The end cut.

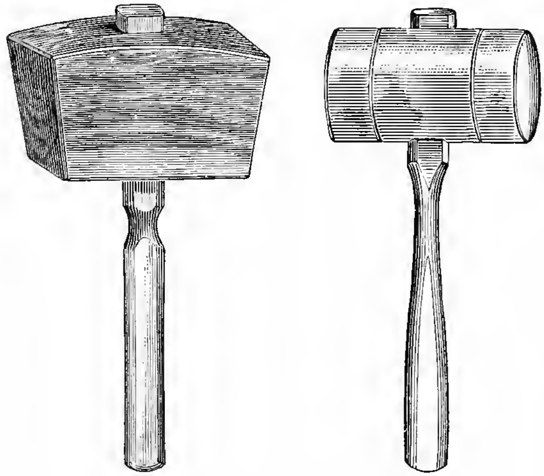


Fig. 70d—Types of Mallets

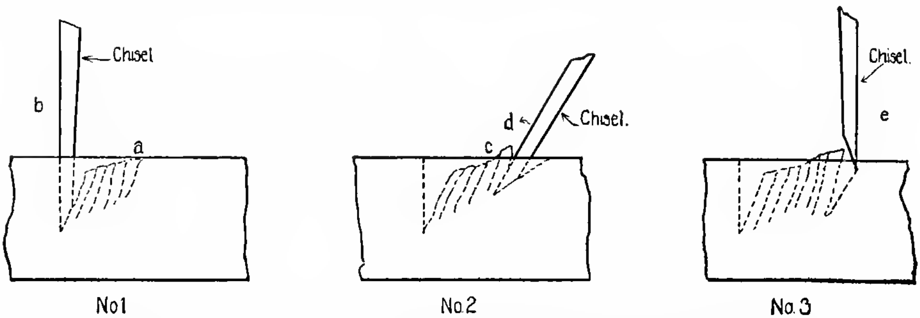


Fig. 70e—Nos. 1, 2, and 3, Fig. 70e, Show Positions of Chisel in Cutting Mortise

and forces considerable material out of the mortise. With the chisel still held in the position *d*, No. 2, take cuts about three-sixteenths of an inch apart until within one-sixteenth of an inch from the end line of the mortise. Then turn the chisel, as at *e*, No. 3. The last cut should be square with and parallel to the end of the mortise. Split the chip through the centre, as in Fig. 70*f*. Trim the sides of the mortise, as in Fig. 70*g*. This trimming will allow more freedom for the chisel as well as let all loose chips fall out easily. Do not dig or pry out the chips, but make another series of cuts with the chisel, held as at *d*, No. 2, Fig. 70*e*. Split the chips and trim the sides of the mortise the same as in the first cut.

Splitting the chips and trimming sides of mortise.

Do not dig out chips.

Fig. 70f—Splitting the Chips with the Chisel

Fig. 70g—Trimming Sides of Mortise with Chisel

These two series of cuts should remove, or at least cut, the stock to the centre. Turn the piece in the vise and repeat all the above operations on the opposite side. When completed these cuts will leave a rough hole through the piece. There should be from one-thirty-second to one-sixteenth of an inch of stock between the hole and the sides and ends of the mortise (Fig. 70*h*). To remove the remaining stock, place the piece in

Chisel from both sides to the centre.

Finishing the mortise.

the vise and hold the chisel as in Fig. 70*i*. Bevel to the lines on both sides. Pare the ends to the centre with a chisel at least one-sixteenth of an inch smaller than the width of the mortise, and extend the bevel in the end from each side to the centre (Fig. 70*j*). The piece will then be as in Fig. 70*k*. Pare the ends and sides until they are a true plane and the lines have been split on both sides. *The chisel cut should always be to the centre from each side.* If the cut is made through from one side to the other, the wood will be split on the side toward which the chisel is cutting, for there will be no support to the fibres on that side. To test the surface the edge of the chisel may be used as a straight-edge the same as the try square is used in making a working face. (See Fig. 70*l*.) Care should be taken to make all corners square.

Chisel to the centre from each side.

Fig. 70h—Rough-Cut Mortise

Fig. 70i—Bevelling to Side Lines of Mortise

Get the best light possible.

The manner of holding the piece in the vise while chiselling depends so much on the position of the light that no general rule can be given, except to say that the lines on the piece and the cutting edge of the chisel must be seen at all times. A little experience will lead to the best method under the existing conditions.

Fig. 70j—Bevelling to End Lines of Mortise

Fitting the mortise and tenon.

When the mortise is finished, cut the two pieces apart, square the ends, and saw to the required length. Push the tenon into the mortise. It should require a light blow with the hammer to force the tenon the last quarter of an inch. Face

Planing end of tenon.

No. 1 on each piece should be adjacent and the shoulders of the tenon should fit against Face No. 2 of the mortise piece. The end of the tenon will extend three-sixteenths of an inch beyond the face of the mortise piece, because all measurements have been made from measuring line $a—a^2$ No. 1, (Fig. 70*b*, page 50), which is three-sixteenths of an inch from the end. Plane this extending end flush with the face, as was done with the lap joint, page 47, Figs. 69*c* and 69*d*, and the joint is finished.

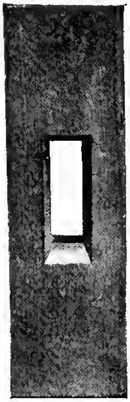


Fig. 70k—Sides and Ends of Mortise Pared to Lines with Centre High

Fig. 70l—Chisel Used as Straight-Edge to Test Side of Mortise

As stated on page 51, there are two ways of removing the bulk of the stock of the mortise—chiselling it out, as given above, and boring it out with an auger bit.

To Remove the Bulk of the Stock in a Mortise with an Auger Bit

The size of an auger bit.

This operation brings into use two new tools—the auger bit and the brace. These are tools for making a round hole in wood. The bits range in size, by sixteenths, from one-quarter of an inch to one inch, with special bits for larger holes. The size of the bit is always stamped on the stem or shank, as 4, 5, 6, etc., meaning $\frac{4}{16}$, $\frac{5}{16}$, $\frac{6}{16}$, etc. The brace is a handle by means of which bits of all sizes are forced into the wood. More will be said about bits and braces in the chapter on tools.

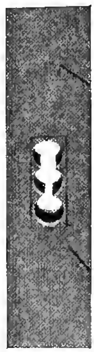


Fig. 71—Stock Rough Cut from Mortise with Auger Bit

Selection of bit.

To remove the required stock, select a bit about one-sixteenth of an inch less in diameter than the width of the mortise to be cut, and bore holes as close together as pos-

Squaring the bit.

sible (Fig. 71). To be sure that the bit will go straight through the piece and come out between the lines on the opposite side, place the try square on the piece, as in Fig. 71*a*, and hold the bit parallel to the blade of the square. Line the bit from the side also. The bit should not be forced entirely through the piece from one side or it will split the wood as it comes through. When the point or spur comes through turn the piece over and finish the hole from the opposite side. Or if a block is placed back of a piece, as in Fig. 71*b*, it will take the pressure and prevent splitting. When the holes are drilled the remaining portion of the stock is removed the same as when roughed out with a chisel.

Boring through the stock.

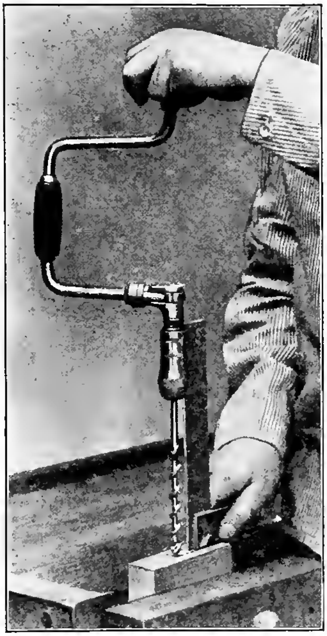


Fig. 71a—Squaring Auger Bit with Try Square

Object of work.

The cutting out of the mortise is all that is really new in this chapter. The chief object of the chapter is to show the necessity for carefully planning and laying out a piece before the cutting tools are used, and incidentally to emphasize again the correct choice of tools for a given piece of work.

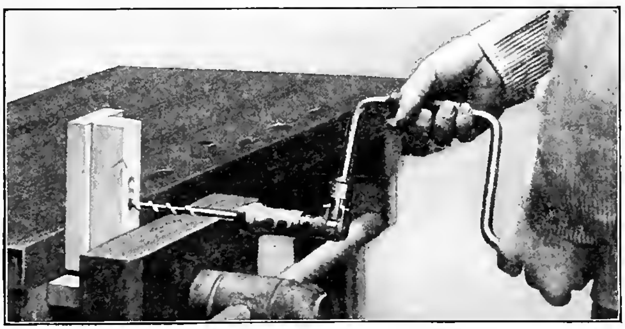


Fig. 71b—Boring into Block

CHAPTER IV

JOINTS AND OTHER MATERIALS USED IN WOOD-WORK

THE mechanical elements given in the previous chapters are the basis of all mechanical work. Stated briefly again, these elements are: (1) Knowledge of the problem with ability to state it accurately. (2) Knowledge of available material. (3) Skill in selecting and using the available tools. If we have followed carefully the steps given in the last three chapters and have done enough of the work to have in mind the method of procedure, it will not be difficult to use the knowledge we have gained in the solution of other mechanical problems, even though a great deal of adjustment is necessary to meet the requirements of the problem under consideration. Mechanical elements. Adjustment necessary.

The object of the following chapter is not to give a complete course in the various methods of joining wood, but to give briefly some of the most common forms of wood construction, including a few of the materials other than wood that are used in wood-work. A few tables and general facts are given which are intended to show the usual method of purchasing materials. Object of chapter.

The joints given on pages 58, 59 and 60 are drawn both in the perspective, or picture, and in the mechanical drawing. On pages 60 and 62 the joints are drawn only in the perspective, while on pages 64 and 65 only the mechanical drawings are used. The object of using both methods of drawing is to give the beginner power mentally to see the mechanical drawing from the object or picture, the necessary faculty for producing the mechanical drawing, and to see the

perspective from the mechanical drawing, a very useful faculty in working from the mechanical drawing to produce the required object.

Half lap tee joint. **End lap joint.**

On pages 58 and 59 are given a number of modifications of the lap joint. Figs. 72 and 72*a* are the perspective and mechanical drawings respectively of the Half Lap Tee Joint considered on pages 35 to 37, inclusive. This joint is used for joining framework on large timbers and on drawer supports, stays, etc., in cabinet work. Figs. 73 and 73*a*, the End Lap Joint, may be used in corner construction, as is shown in the figure; or it may be used in joining pieces end to end as in 74. When made long, as in 74*a*, it is used as a timber splice. For this latter purpose the joint is made in many different ways. By referring to the subject, "Building," in any good encyclopædia, a number of such splice joints will be found.

Middle lap joint.

The Middle Lap Joint, Figs. 75 and 75*a*, is used in framing where one piece crosses the other and the thickness of the joint is not more than the thickness of one of the pieces of which it is made.

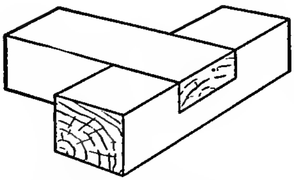


Fig. 72—Perspective Drawing of Half Lap Tee Joint

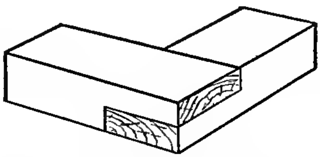


Fig. 73—Perspective Drawing of End Lap Joint

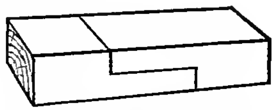


Fig. 74—Perspective Drawing of Splice Joint

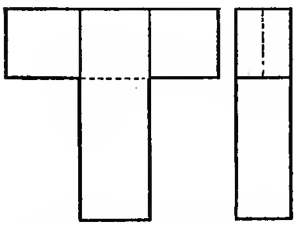


Fig. 72a—Mechanical Drawing of Half Lap Tee Joint

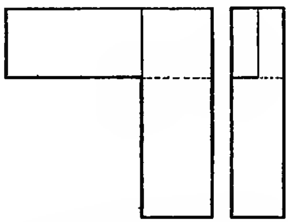


Fig. 73a—Mechanical Drawing of End Lap Joint

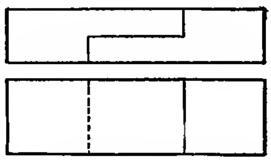


Fig. 74a—Mechanical Drawing of Splice Joint

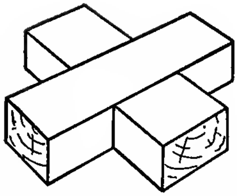


Fig. 75—Middle Lap Joint

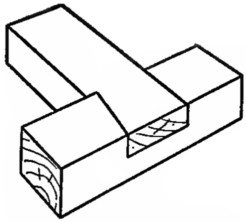


Fig. 76—Half Dove-Tail Joint

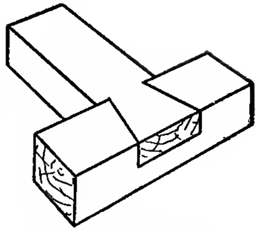


Fig. 77—Dove-Tail Joint

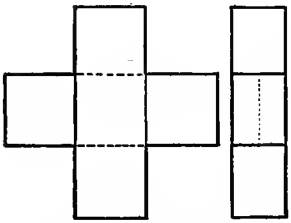


Fig. 75a—Mechanical Drawing of Middle Lap Joint

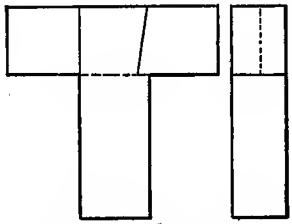


Fig. 76a—Mechanical Drawing of Half Dove-Tail Joint

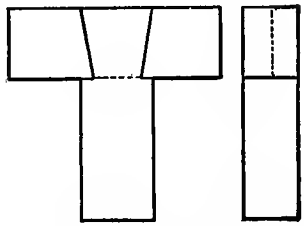


Fig. 77a—Mechanical Drawing of Dove-Tail Joint

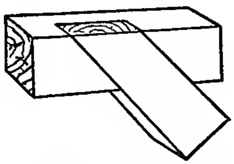


Fig. 78—Brace or Angle Joint

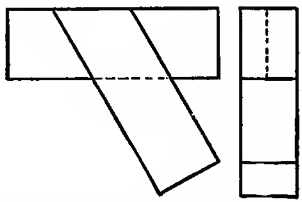


Fig. 78a—Mechanical Drawing of Brace or Angle Joint

Dove-tail joint.

Figs. 76 and 76*a*, Figs. 77 and 77*a* are forms of the Dove-Tail Joint. They are also modifications of the Lap Joint and are made to withstand a tension or pull as well as a compression or push. Figs. 78 and 78*a* represent the Brace Joint. They are used for bracing or framing at an angle.

Brace joint.

A number of the mortise and tenon type of joints are given on page 60.

Mortise and tenon joints.

Figs. 79 and 79*a* are the Through Mortise and Tenon Joint, the construction of which was given in detail on pages 46 to 56, inclusive.

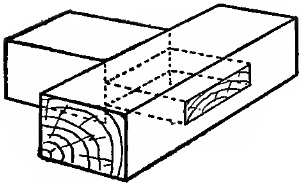


Fig. 79—Through Mortise and Tenon Joint

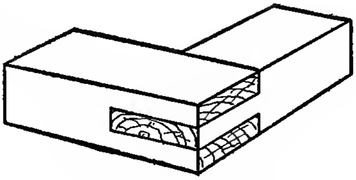


Fig. 80—Slip Mortise and Tenon Joint

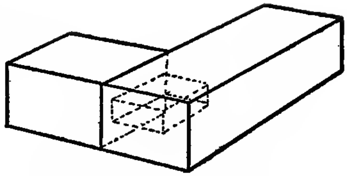


Fig. 81—Blind Mortise and Tenon Joint

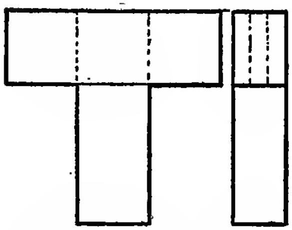


Fig. 79a—Mechanical Drawing of Through Mortise and Tenon Joint

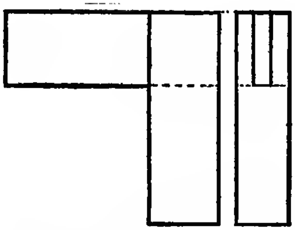


Fig. 80a—Mechanical Drawing of Slip Mortise and Tenon Joint

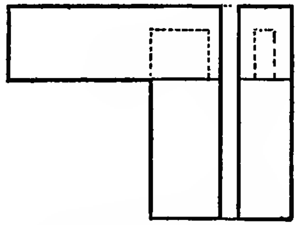


Fig. 81a—Mechanical Drawing of Blind Mortise and Tenon Joint

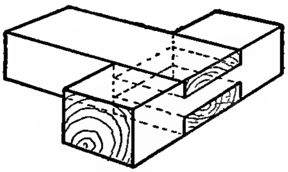


Fig. 82—Slip Mortise and Tenon Joint

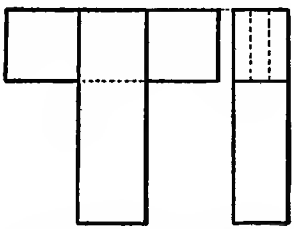


Fig. 82a—Mechanical Drawing of Slip Mortise and Tenon Joint

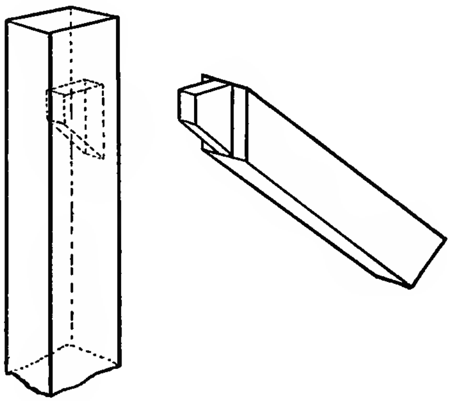


Fig. 83—Brace Joint

This form of joint is used in framing, where the end of the tenon will not make an unsightly scar on a finished surface.

The Slip Mortise and Tenon Joint (Figs. 80 and 80*a*) is used on window-screen frames, window-sash, door frames, etc., where the edges are not visible. The Blind Mortise and Tenon Joint (Figs. 81 and 81*a*) is made in many forms and is used more than any single form of joint yet considered. As shown in the cut, this joint is used for end framing. If made, as in Fig. 79, with the tenon blind, that is, entirely concealed within the cross-piece, it is used in place of the Through Mortise and Tenon. The Blind Joint is used on chairs, tables, cabinets, desks, and, in fact, on nearly every form of cabinet work. Figs. 82 and 82*a* show a form of the Slip Joint (Fig. 80), the use of which is suggested by the drawing. Fig. 83 is a Brace Joint.

Slip mortise and tenon.

Blind mortise and tenon.

Brace joint.

Butt Joints

Joining at right angle. Fig. 84 is the Plain Butt Joint used in rough work and is held by nails or screws. Fig. 85 is a Rabbeted Joint, used a great deal in making drawer corners where it is not desirable to have the end grain of the side piece show. Fig. 86 is a modified form of Fig. 85. It is used for the same purpose as Fig. 85 and also for box corners. Fig. 87 is a Housed Joint, used where Figs. 85 or 86 would not give the required strength and where the projecting ends are not objectionable—for example, watering troughs—and if bolted, as shown at *A*, Fig. 87, it is used on large vats and tanks. Fig. 88 is a matched corner, used mostly for box corners. Fig. 89 is the Dove-Tail, used for box corners, drawer corners, etc., where considerable strength is required. It is a difficult joint to make by hand.

Plane butt joint.

Rabbeted joint.

Housed joint.

Matched corner.

Dove-tail.

Miter Joints

The Miter Joint is used where it is not desirable to have the end grain show at all. It is not a strong joint, and the only differences in the forms of it are made in order to get a better fastening.

Plain miter joint.

Fig. 90, the Plain Miter Joint, is held together by nails and glue, and is used mostly for small picture-frame work. Figs. 91 and 92 show other methods for fastening the miter joints. *A*, Fig. 91, is a strip of wood set in grooves between the two pieces. This inserted piece is called a *feather* or a *spline*, and the grain should be placed in the direction of the arrow to prevent splitting. *B*, Fig. 92, is merely a

Feather or spline.

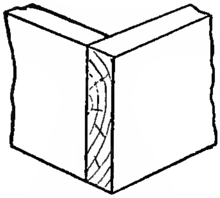


Fig. 84—Plain Butt Joint

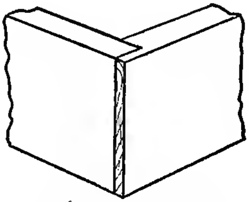


Fig. 85—Rabbeted Joint

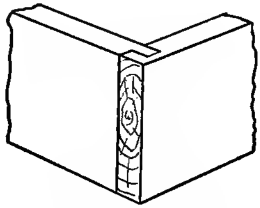


Fig. 86—Gain Joint

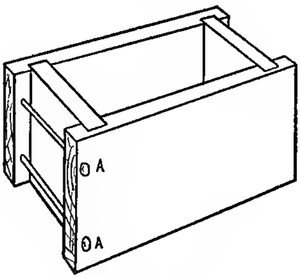


Fig. 87—Housed Joint

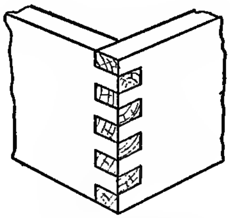


Fig. 88—Matched Joint

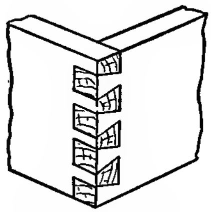


Fig. 89—Box Dove-Tail Joint

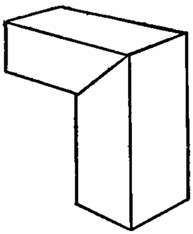


Fig. 90—Plain Miter Joint

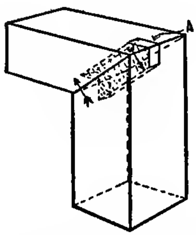


Fig. 91—Miter Joint Fastened with Spline

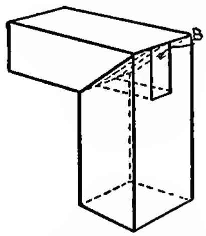


Fig. 92—Miter Joint with Mortise and Tenon

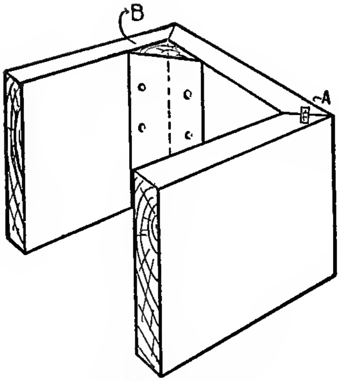


Fig. 93—Miter Joints Used as Box Corners

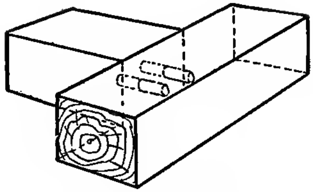


Fig. 94—Butt Dowel Joint

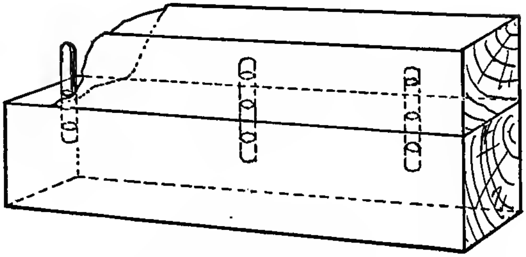


Fig. 95—Edge Dowel Joint

tenon. *A*, Fig. 93, shows the miter used as a box corner with the spline placed in a different position; *B* shows a common method of reinforcing a miter joint in a box or drawer corner. **Miter joint for box corner.**

Dowel Joints

Figs. 94 and 95 are examples of the Dowel Joint. The round pin used as a fastening device is called a dowel. Fig. 94 is not a strong joint and is used only on small or cheap work. Fig. 95 is a common method of uniting two pieces edge to edge or in the direction of the width. Such a joint is usually set in glue, and if well made it is a good joint.

Method of Uniting Boards in the Direction of Their Width

Fig. 96 is an Edge Butt Joint. If well glued in soft wood this makes a good, strong joint, but if the pieces are long it will be difficult to keep them in line without the use of some such device as that shown in **Edge butt joint.**

Rabbeted edge joint. **Spline joint.** **Matched joint.**

Figs. 98 and 99, or the Dowel Joint, Fig. 95. Fig. 97 is the Rabbeted Joint. The corner cut (*A*) is called the rabbet. This joint is usually set in glue and is used on backs of desks, bookcases, etc. Fig. 98, the Feather or Spline Joint, is not much used, but may be used in place of the joint shown in Fig. 97 or 99. Fig. 99 is the Matched Joint, and is used more than all of the other forms of the same type. It is used for flooring, wainscoting, table tops, side pieces for cabinets, etc., and in fact in all places where it is necessary to unite edges.

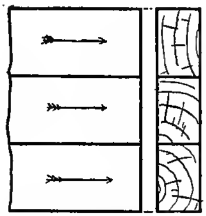


Fig. 96—Edge Butt Joint

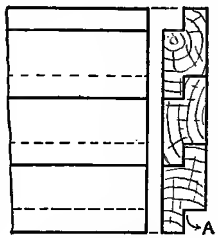


Fig. 97—Rabbeted Joint

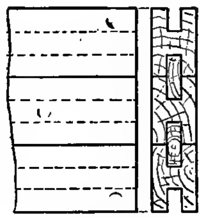


Fig. 98—Feather or Spline Joint

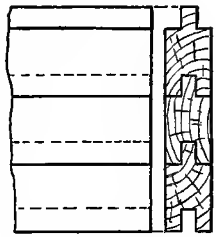


Fig. 99—Matched Joint

Cleating

Side cleats. **End cleats.** **Cabinet cleating.**

Strips of wood used as *A*, Figs. 100, 101, and 102, page 65, are called cleats. As used in Figs. 100 and 101, the cleats are to prevent warping and to reinforce the butt joints between the boards. They are fastened with nails or screws, as in Fig. 100. Fig. 101, End Cleating, is not so strong as is Fig. 100, but the cleats are out of the way and do not increase the thickness of the piece. This form of cleating is used on drawing-boards, cake boards, etc. Fig. 102, Cabinet Cleating, shows a method of fastening the top on a cabinet, holding the end of a shelf, and for drawer supports, etc.

Screw-eye substitute for cleat.

On small work, where cleats, as shown in Fig. 102, would look out of place, a good substitute for the cleat is the screw and screw-eye,

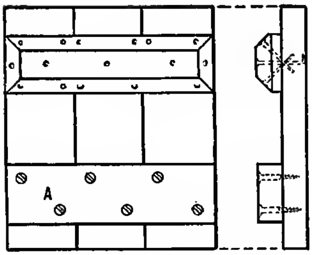


Fig. 100—Side Cleating

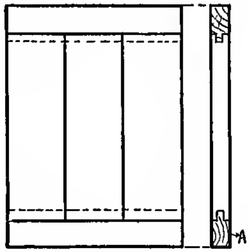


Fig. 101—End Cleating

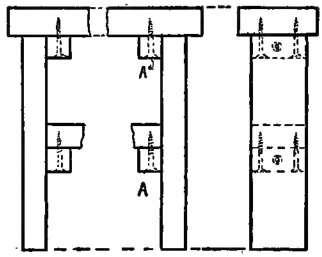


Fig. 102—Cabinet Cleating

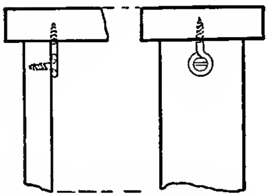


Fig. 103—Screw and Screw Eye Substituted for Cleating

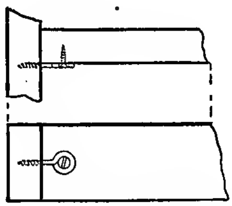


Fig. 104—Screw and Screw Eye Substituted for Cleating

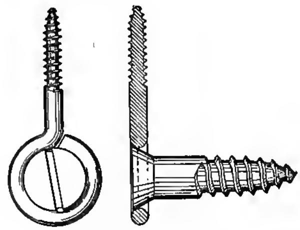


Fig. 105—Screw and Screw Eye

Fig. 105, used as is shown in Figs. 103 and 104. If used with a Housed Joint (Fig. 87, page 62) the screw-eye in place of the cleat makes a good, strong joint.

Miscellaneous Joints

Fig. 106, is a form of corner joint which can be used in large boxes. The screws used are of the lag screw type, Fig. 122, page 74. Fig. 107 is a dowel joint reinforced with a carriage bolt (*B*). This is a good joint for a portable bench. By removing the nut on the bolt the joint may be taken apart easily.

Lag screw for box corner.

Reinforced dowel joint.

Fig. 108 is a form of the Mortise and Tenon Joint and is also easily taken apart. The joint is a good one for small furniture that is to be moved often. *A* is called the key, and the joint is called the Keyed Joint.

Keyed joint.

In the first part of this chapter brief mention was made of devices other than joints for holding pieces of wood together. Joints alone may be sufficient in simple pieces where there is no strain upon them,

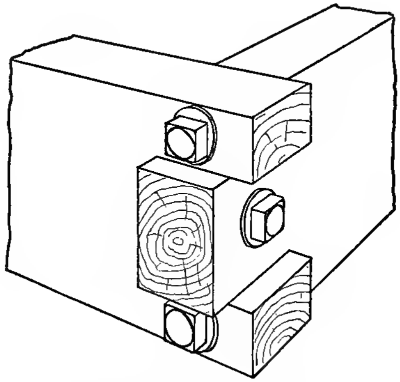


Fig. 106—Lag-Bolt Joint for Large Box Corners

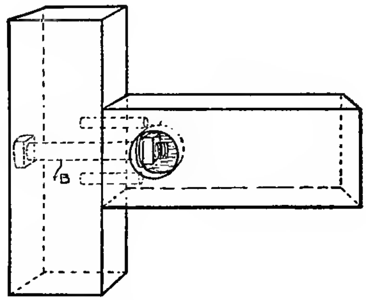


Fig. 107—Reinforced Dowel Joint

but if we wish to build large or strong articles, merely placing the joined parts together will not give the required strength. It will be necessary, therefore, to hold the parts in place by some other means. In some cases these other forms of fastenings will give sufficient strength without the joint at all. The most common methods of fastening pieces of wood together are by means of nails, screws, and glue, which we will now consider.

Most common methods of fastening wood.

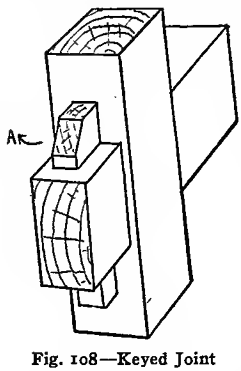


Fig. 108—Keyed Joint

Nails

At one time all nails were made by hand by the blacksmith. This was a slow process and gave way to the machine-cut nails, as shown in *A* and *B*, Fig. 109. *B* is the common nail, with a large head, for use on large, rough work, while *A*, as is seen in the cut, has a much smaller head, one that will

Cut nails.

not leave a large scar. For this reason *A* is called the finishing nail and is used for delicate finishing work. These nails are wedge shaped, and care must be taken in driving them or they will split the wood. Cut nails are now practically out of the market. We shall, therefore, not consider them further, but shall consider the wire nail with which we are all familiar. Cut finishing nails.

The wire nail is made by upsetting a head on the end of a piece of steel wire. It is much better than the old cut nail in that it is round Wire nails.

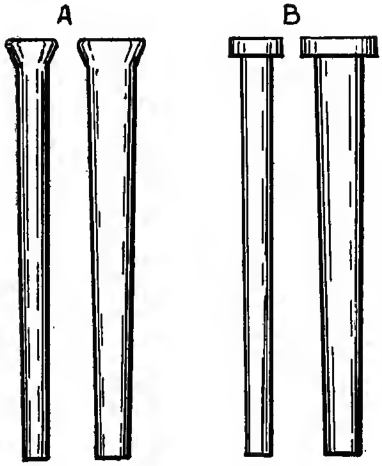


Fig. 109—Cut Nails

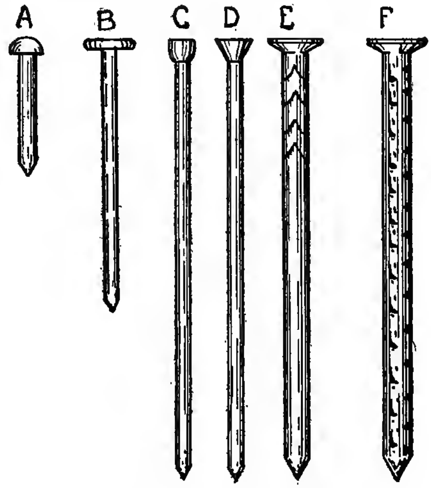


Fig. 110—Types of Wire Nails

and will not split the wood, and by being the same size throughout the entire length it holds into the wood much better. Wire nails are made in very many sizes and shapes to meet a great number of different conditions. The common or standard nail (*E*, Fig. 110) is made in a number of sizes, a table of which follows. In designating the size of standard nails the word "penny" preceded by a number is used as, 2 penny, 3 penny, 4 penny, etc. In writing an order the word penny is abbreviated by the letter "d," and is Size of nails. Order for nails.

written 2d, 3d, 4d, etc., but read 2 penny, 3 penny, 4 penny, etc. The following is a table of sizes and lengths of the standard wire nails:

TABLE OF NAIL SIZES AND LENGTHS

Size	2d	3d	4d	5d	6d	7d	8d	9d	10d	12d
Length in inches	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{4}$

Size	16d	20d	30d	40d	50d	60d
Length in inches	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6

Wire finishing nails.

D, Fig. 110, is a wire finishing nail with a small head and a slim body, which corresponds to the cut finishing nail, *A*, Fig. 109. *C*, Fig. 110, is a brad. The brad has a head made somewhat different from the head of the finishing nail and is smaller in diameter. Brads range in length from $\frac{3}{8}''$ to $2\frac{1}{2}''$, and the diameter is given by the number of the wire from which they are made. The *larger the number* the *smaller the brad*. Brads are used on very small, delicate work. An order for brads is written as follows: $\frac{5}{8}''$ No. 19, $\frac{3}{8}''$ No. 20, or $2\frac{1}{2}''$ No. 12, etc. *B*, Fig. 110, is a special box nail. *A* is an escutcheon pin, usually made of brass, and is used for putting on small hinges, catches, locks, curtain hangers, etc. The sizes of escutcheon pins range in length and diameter according to the use made of them. *F* is a standard nail with barbs on it to make it hold better. The clout nail (*B*, Fig. 111) is made of soft iron, so that it can be clinched without breaking, as in *C*, Fig. 111. *A*, Fig. 111, is a trunk nail. It is made the same as the clout nail, with the exception that it has a round instead of a flat head. The clout nail is usually galvanized to prevent rust, and ranges in length from $\frac{1}{2}''$ to $1''$ by a difference of $\frac{1}{8}''$ to the size, and may be had longer than $1''$.

Size of brads and how to order them.

Escutcheon pins.

Clout and trunk nails.

Tacks

Size of tacks.

While tacks are of no value in fastening pieces of wood, they are indispensable in upholstering work of all kinds. A table of sizes and lengths is given below. The size of tacks is given by the word ounce, preceded by a number, as 1 ounce, 2 ounces, 3 ounces, etc. The word "ounce" has the usual abbreviation (oz.). Tacks may be bought loose by the pound or in small boxes.

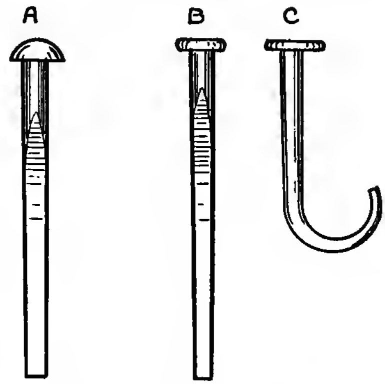


Fig. 111—Trunk and Clout Nails

There are so many sizes and special makes of nails and tacks that we should consult a dealers' catalogue in order to learn what will best meet the special requirements when doing a piece of work out of the ordinary. There are no general rules governing the selection of nails; they must be selected according to the requirements of the work in hand.

TABLE OF STANDARD SIZES OF CUT TACKS

Length in inches.................	$\frac{3}{16}$	$\frac{3\frac{1}{2}}{16}$	$\frac{4}{16}$	$\frac{5}{16}$	$\frac{6}{16}$	$\frac{7}{16}$	$\frac{8}{16}$	$\frac{9}{16}$	$\frac{10}{16}$	$\frac{11}{16}$	$\frac{12}{16}$	$\frac{13}{16}$	$\frac{14}{16}$	$\frac{15}{16}$	$\frac{16}{16}$	$\frac{18}{16}$
Size in ounces.....................	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	4	6	8	10	12	14	16	18	20	22	24

Hammers

There are many sizes and shapes of hammers. The common claw hammer (Fig. 112) is the one most used by the wood-worker. Hammers are catalogued as follows:

Sizes of hammers: Nos. 1, $1\frac{1}{2}$, 2, 3. Size of hammer.

Weights, without handle: No. 1, 1 lb. 4 oz.; No. $1\frac{1}{2}$, 1 lb.; No. 2, 13 oz.; No. 3, 7 oz.

Bell-face and plane-face hammers.

Hammer No. 2—13 oz.—is a convenient size for general use. Fig. 112, *a*, is a plane-face hammer and *b* is a bell face. The bell-face hammer usually has a better balance, or as the mechanic would say, it is hung better than the plane face.

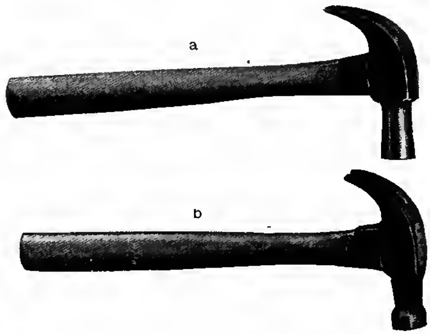


Fig. 112—Types of Hammers

The hole in which the handle is placed is called the Eye of the hammer. Hammers having the eye extended, as those in Fig. 112, are called adze-eye hammers. Hammers made with the adze-eye hold the handle better than does the hammer made without it. The first cost of the adze-eye hammer is more, but the handle holds so much better that they are the most economical.

Driving a nail.

When driving a nail the hammer should be held by the end of the handle and the arm should swing from the shoulder instead of from the elbow. The proper use of the hammer is an art which is learned only by experience.

With-drawing a nail.

To withdraw a nail it should be pulled in a straight line. A nail properly withdrawn will not be bent. To withdraw a nail, place a block under the head of the hammer, as in Fig. 113. The block will keep the pull straight and will prevent the hammer from marring the surface of the work.

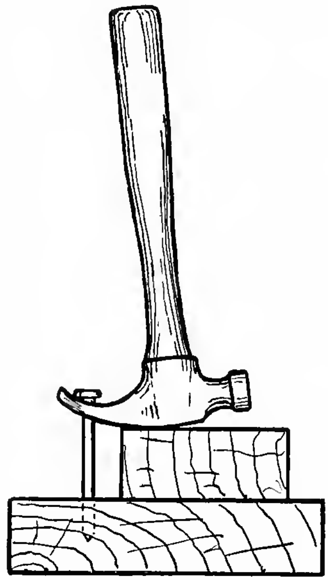


Fig. 113—Withdrawing Nail

Nail set.

Hammer marks on the surface of the work should be avoided. The oval face of the hammer will set the nail level with the surface of the wood, but if it is desired to set the head below the surface, the nail set (Fig. 114) should be used. The point of the nail set is cupped and has sharp edges, as is shown in the sectional view (*A*, Fig. 114). To sink the head of the nail below the surface or, as is usually said, to set the nail,

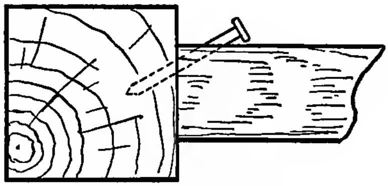


Fig 115—Toe Nailing

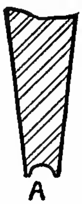


Fig. 114—Nail Set

the nail set is placed on the head and struck a sharp blow with the hammer. The sharp edge of the nail-set point will prevent it from slipping off the head of the nail. When a nail is driven obliquely, as in Fig. 115, it is said to be toed. Such nailing is spoken of as toe nailing.

Toe nailing.

Standard Wood Screws

Flat and round head screws.

Wood screws are of two general types, flat head and round head. (Fig. 116.) They are made of brass and steel. To prevent rusting and to improve their appearance, steel screws are *blued*, *galvanized*, or *copper plated*. Both steel and brass screws are *nickel plated*. Brass will not rust and is plated only to improve its appearance. Steel screws are blued by heating highly polished screws until they turn blue. The heating covers the screw with a coating of iron oxide. Galvanizing is merely zinc plating.

Finish of screws.

The sizes of screws are designated by the length in inches and

a number which refers to the diameter. Each length of screw is made in several different diameters, as is shown by the table of standard screws given below.

Order for screws.

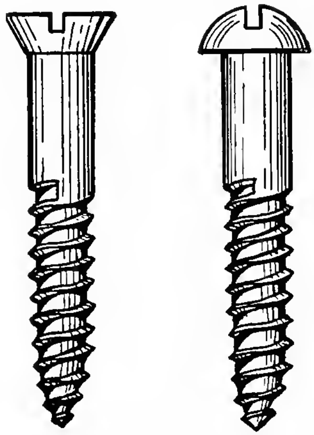


Fig. 116—Types of Wood Screws

Screws are usually sold in boxes containing one gross, but may be bought in bulk by the pound, or in small quantities by the dozen. From the table of standard sizes, given below, and from the facts mentioned above, it is evident that an order for screws must give the following information:

Quantity wanted.
Length.
Number (diameter of screw).
Type (round or flat-head).
Finish (bright, blued, galvanized, copper-plated or nickel-plated).

TABLE OF STANDARD SCREW SIZES AND LENGTHS

LENGTH	¼″	⅜″	½″	⅝″	¾″	⅞″	1″	1¼″	1½″	1¾″	2″	2¼″	2½″	2¾″	3″	3½″	4″	4½″	5″	6″
NUMBER	0																			
	1																			
	2	2	2																	
		3	3	3																
		4	4	4	4															
		5	5	5	5															
		6	6	6	6	6														
		7	7	7	7	7	7													
			8	8	8	8	8	8												
			9	9	9	9	9	9	9											
				10	10	10	10	10	10	10										
					11	11	11	11	11	11	11	11								
					12	12	12	12	12	12	12	12								
							13	13	13	13	13	13								
							14	14	14	14	14	14	14							
								15	15	15	15	15	15		15					
								16	16	16	16	16	16	16	16		16			
									17	17	17	17	17		17					
									18	18	18	18	18	18	18	18	18			
										20	20	20	20	20	20	20	20	20		
																22			22	
																				30

An order for screws is written as follows: 5 gross—$\frac{7}{8}''$—number 10—Flat-Head, Blued Steel screws. The order is usually abbreviated as follows:

5 gr.—$\frac{7}{8}''$—No. 10—F. H. Blued Steel screws.
25 boxes—$1\frac{1}{2}''$—No. 12—R. H. Gal. Steel screws.
2 doz.—$1\frac{1}{2}''$—No. 8—F. H. Brass screws, etc., etc.

Screws are used for fastening pieces of wood together usually where more strength and better work are wanted than can be obtained Use of screws.

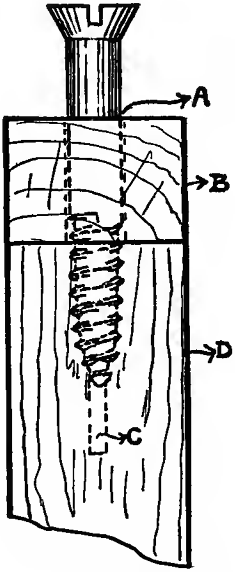


Fig 117—Fastening with Screw

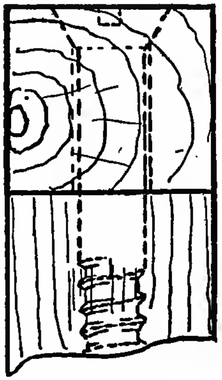


Fig. 118—Countersunk Screw Head


Fig. 119—Rose Countersink

by the use of nails, and for fastening locks, hinges, catches, etc. As is the case in all construction, the problem in hand must determine the screws to use.

If two pieces are to be fastened, as in Fig. 117, or in any other way, the hole *A* in the piece corresponding to *B* should be large enough Fastening by means of screws.

to allow the screw to pass through easily, though not loosely. If the screw is screwed into the piece *B* it will wedge itself into that piece and will not draw *D* up to *B*. If the wood is hard, or likely to split, a small hole, as *C*, piece *D*, should be drilled, into which the screw may be screwed.

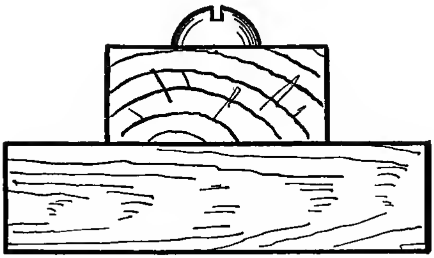


Fig. 120—Head of Round-Head Screw. Stands Above the Surface

Counter-sinking the flat-head screw.

The head of a flat-head screw is always set into the wood, as in Fig. 118. This is called counter-sinking the screw head. A tool called the countersink (Fig. 119) is used to bore out the place for the head of the screw. There are several types of countersinks, but the one given in Fig. 119, the Rose countersink, is the one in most general use. The counter-sink is held in a brace and is turned the same as an auger bit when

Counter-sink.

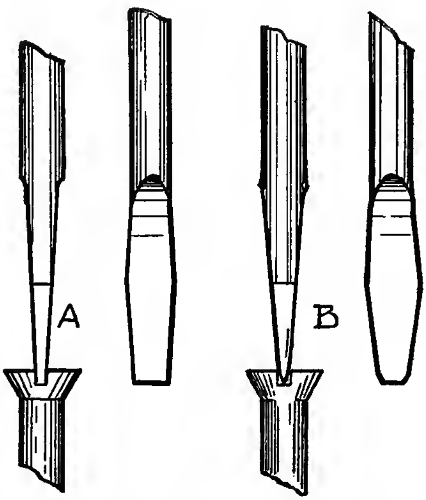


Fig. 121—A, Correct; B, Incorrect Screw-Driver Point

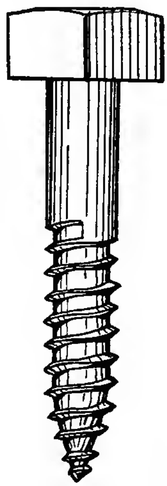


Fig. 122—Lag Bolt or Screw

drilling a hole. The head of the round-head screw is left above the surface of the wood, as in Fig. 120.

The Screw-Driver, the tool used for driving, that is, screwing the screw into the wood, is, like all other tools, made in a great variety of special shapes and sizes. The most essential feature of a screw-driver is that the end of the blade fit the slot in the screw to be driven, as in *A*, Fig. 121, and never as in *B*. If a screw-driver slips out of the screw slot and marks the head of the screw, the point is probably not formed correctly.

Screw-driver.

Shape of screw-driver point.

One other type of screw, the lag screw (Fig. 122), is of much use to the bench worker. This screw ranges in sizes from $1\frac{1}{2}''$ to $12''$ in length, and from $\frac{5}{16}''$ to $\frac{3}{4}''$ in diameter, with special sizes to order. As is shown in the cut, it has a square head and is driven with a wrench. The lag screw is used where great strength is needed.

Lag screw.

Glue and Gluing

Most commercial glues are of two kinds—animal glue and fish glue. Animal glue is obtained from bones, hoofs, horns, and scraps of hides—the refuse of the large slaughter-houses and tanneries. Fish glue is taken from the scales, spawn, and intestines of fish—the refuse of the large fisheries. Both kinds of glue are placed on the market in the form of hard, brittle bars and cakes broken to small dimensions and packed loose in boxes and barrels.

Animal and fish glue.

To Prepare Glue for Use

Both animal and fish glues are prepared for use in the same way. Place the required amount of hard glue in the inner pot of a double boiler—the regular commercial glue-pots are best for this purpose—pour over the glue a small amount of cold water and allow it to soak until soft. Heat by placing the pot in the hot-water jacket of the

glue-pot. The dish containing the glue should never be placed directly over the fire, for fear of burning, nor should the glue be kept in hot water for a long time. Continued heating will decompose the gelatine and render the glue valueless. When the glue is thoroughly dissolved, enough water should be added to make it to the consistency of thin syrup. Glues prepared in this way should always be used hot, for as soon as they commence to cool they begin to set; that is, they commence to get hard.

Directions for Gluing

Holding devices for gluing.

All parts to be glued must be fitted and ready for placing in the final position. Each part should be *marked* so that it may be put into position quickly. *All clamps and holding devices should be adjusted and ready for placing in position.* When all is ready, glue should be applied in a thin coating over all the surfaces that are to be joined. When the glue is on the parts, place them together quickly, put the clamps or other holding devices into place, and draw them up until all the surplus glue is squeezed out of the joints. The clamps must be left in position until the glue is thoroughly hard. This will require several hours, varying according to the size of the pieces glued.

Liquid Glues

There are a number of glues on the market in a liquid form, which are prepared ready for use. If but a small amount of gluing is to be done, the liquid is more convenient than the hot glue, and its use is recommended. The liquid glues are, however, more expensive, require a longer time to set, and are more affected by excessive moisture than are the hot glues.

Sizing with Glue

When gluing end grain with either kind of glue, a thin coat should be applied and allowed to soak into the wood and harden before the final gluing is attempted. If the glue is applied and the joint put together at once the glue will draw back into the pores of the wood and will be of no service in the joint. This dressing with thin glue is called sizing.

Effect of heat and moisture on glue.

Glue joints will not stand excessive heat or moisture and are likely to give way under a heavy blow, but if reinforced with screws or other fastening devices the glue adds materially to the strength of a joint and is indispensable in good cabinet work.

Tools Used in Gluing

Means of heating glue.

Fig. 123 shows the appliances that make up the ordinary gluing outfit. Glue-pots are heated by any convenient means—on a stove,

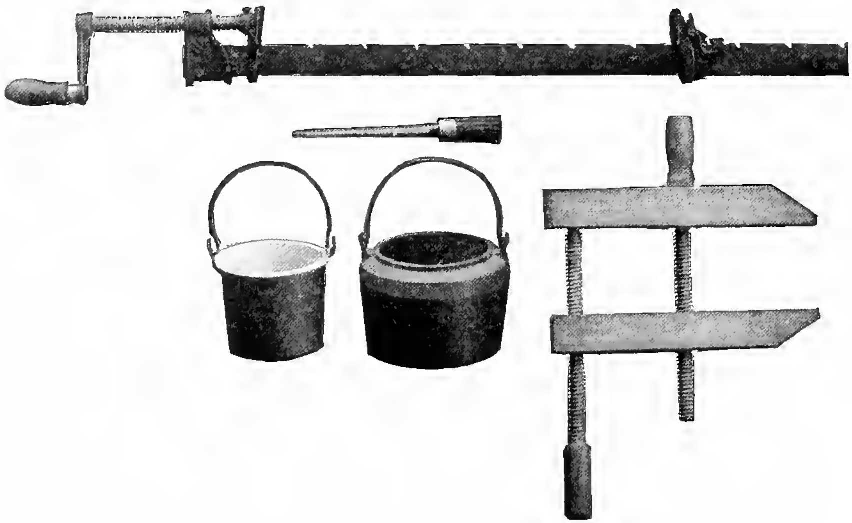


Fig. 123—Gluing Outfit. Photograph Showing Glue-Pot, Glue Brush, and Clamps

over a gas flame, by steam, etc. If a large amount of gluing is to be done, a permanent heating arrangement should be provided. Special brushes are made for use in glue. The bristles must be very securely fastened in order to stand the heat and moisture. Round-point brushes with bristles fastened with wire are good. On small work a splinter of wood is often a very convenient glue brush.

Brushes for glue.

Hand and bar clamp.

Clamps are of two general types, the hand clamp and the bar clamp. The wood hand clamp is for small work, and ranges in size according to the following table:

Length of jaw in inches........	7	8½	10	12	14	16	18	20
Opens in inches	4	4½	6½	7	7½	9½	10	18½

Bar clamps are for large work and range in size up to five feet, with special arrangements for larger sizes. A dealers' catalogue will give more detailed information and should always be consulted when buying supplies of any kind.

CHAPTER V

TOOLS GROUPED ACCORDING TO THEIR USE

In the first three chapters we have learned considerable about tools and the reasons for choosing certain types for doing particular things. The object of this chapter is to give additional facts about tools, and to group the knowledge that we have gained, so that we can enlarge the field of our work.

Measuring and Laying-Out Tools

Measuring and laying-out tools are so closely related that a number of them are used for both purposes, and for that reason the two subjects will be considered under one heading.

Historical note.

Measuring in its various forms is as old as trade or barter. Linear measure, the kind with which we are now concerned, has been based on many different objects, and even at the present time there are several standards in use in the various countries.

Some of the first objects used as a basis for measurements were the parts of the human body. When Noah was commanded to build the Ark he was told to make it three hundred cubits long, fifty cubits wide, and thirty cubits high. A cubit was the length of the forearm from the elbow to the end of the middle finger. At other times the nail, the hand, and the finger were used, and even at the present time we have the foot as a name at least coming to us from those remote times. When such standards were in use one wonders whose arm was used as a basis for measuring, the arm of the one who was buying or of the one who was selling.

According to the new "International Encyclopædia," the following law was in force in Germany in the sixteenth century:

> "To find the length of a rood in the right and lawful way, and according to scientific usage, you shall do as follows: Stand at the church on Sunday and bid sixteen men to stop, tall and small ones as they happen to pass out when the service is finished; then make them put their left feet one behind the other, and the length obtained shall be a right and lawful rood to measure and to survey the land with and the sixteenth part of it shall be a right and lawful foot."

As trade grew more definite standards were required, and gradually such standards were fixed by law. In 1814 the United States Government had a standard scale made in England and brought to Washington to be used as a copy from which other scales could be made. This was called the Troughton scale because a man by the name of Troughton made it. It was not until 1856, however, that all the States were provided with standard weights and measures.

Troughton scale.

Historical references.

A very interesting history of the weights and measures of the United States is given in the "Report of the United States Coast and Geodetic Survey for 1890," Appendix 18, pp. 736–8, and for a general history of weights and measures see "The Evolution of Weights and Measures and the Metric System," by William Hallock, published by The Macmillan Company, New York.

Rulers.

For many years lumber has been sold by the board foot. Now a board foot of lumber is one inch thick and a foot square. Consequently the standard of measure for all wood-work is the foot. The form of measure most used by the wood-worker is the two-foot rule, which for convenience in carrying has been made to fold together. Rules are designated as twofold, fourfold, sixfold, etc., according to the number of parts of which they are made, and are spoken of as six-inch, one-foot, two-foot rules, etc., according to their length. Wooden rules are usually graduated, that is, marked off into sixteenths, eighths, quarters, halves, and inches. The best wooden rules are bound on the edges with brass to prevent wearing. Nos. 1 and 2, Fig. 124, show the two

and four fold rule, respectively. If made of wood, the measuring tool is usually called a *rule,* if made of steel it is called a *scale.* Steel scales are used for accurate work. The blades of both the try square

Steel scales.

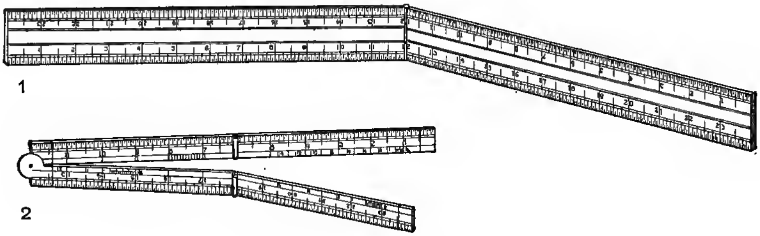


Fig. 124—Types of Rulers

and the framing square are graduated and serve as the steel scales generally used by the bench worker. The correct way of using the rule or scale for locating a measurement is given on page 21, Figs. 39 and 39*a*.

Locating a measurement.

Laying-Out Tools

The gauge, the knife, and the pencil are the tools most used for marking out measurements.

Gauge.—The parts of the gauge are given on page 18, Fig. 32. For the correct way of using and adjusting the gauge, see pages 18 and 19, Figs. 33 to 37 inclusive. The gauge is used only for making lines with the grain parallel to a marked surface.

The gauge and its use.

Knife.—The correct way of using and sharpening a knife for making lines is given on page 21, Figs. 39 to 39*e*, inclusive. See also "Squaring Around a Piece," pages 22 and 23, Figs. 39*f* to 39*j*, inclusive.

The knife and its use.

A medium-size pocket-knife is good for making lines, but it is better to have a special knife that may be used exclusively for that

purpose, such as the one shown in Fig. 125. Such a knife is called a Sloyd knife. This knife is also especially designed for whittling. The knife and the gauge are always used where accurate measurements are required.

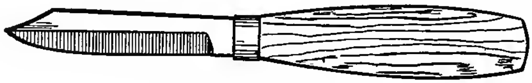


Fig. 125—Sloyd Knife

The pencil as a laying out tool.

Pencil.—The pencil, as a tool for laying out work, has been previously considered on page 4, Figs. 1 and 1*a*, for laying out the first rough lines. It is used where accuracy is not required and for several special operations. For example, if we wish to bevel or round an edge or a corner (Figs. 126 and 126*a*), and should lay out the work with the knife or gauge, as in Fig. 127, it would be necessary to bevel or round to the line *A* in order to remove line *E*. To cut back to *A* would be the same as working without a line.

For the reasons given above,

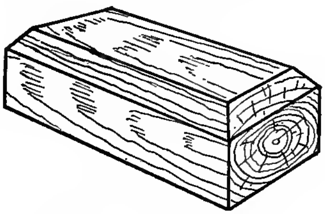


Fig. 126—Bevelled Edges on Block

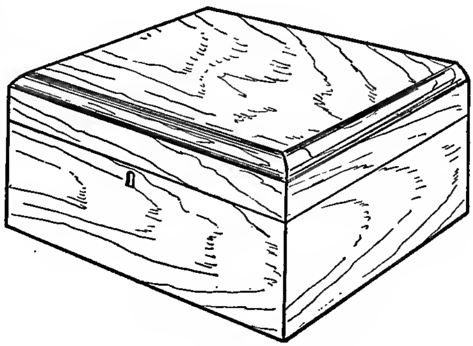


Fig. 126a—Round Edges on Box

it will be evident that the pencil should be used for laying out bevelled and round edges and corners. The pencil may be used against a straight-edge and square the same as the knife, but for rough work which needs only to have a good appearance it may be used as in Fig. 128. The tendency among beginners is to abuse the use of the pencil. *Joint parts and pieces where accuracy is required must not be laid out with the pencil for the line is too coarse.*

Abuse of pencil.

Try Square

The try square, the squaring tool most used by the bench worker, has been described and its use as a surface-testing and squaring tool explained (pages 15, 16 and 17, Figs. 27, 28, and 30); while the use of

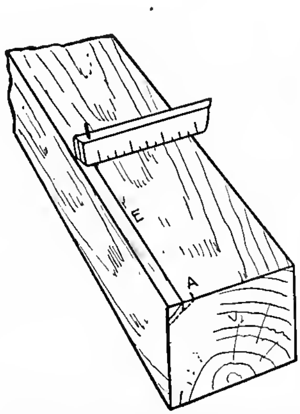


Fig. 127—Incorrect Method of Laying Out Bevelled and Round Edges

Fig. 128—Edge Lining for Round and Bevelled Edges

the square as a straight edge for marking lines is shown on pages 22 and 23, Figs. 39*f* to 39*j*, inclusive. For testing a gauge line with the square, see page 19, Fig. 37.

For squaring an auger bit, see page 56, Fig. 71*a*.

Framing Square.—While the framing square is a tool used mostly by the carpenter and builder, it is also of much use to the bench worker. The ordinary framing square is made with one blade 24″ long and one 16″ long. It is usually graduated on one side in $\frac{1}{32}''$, $\frac{1}{16}''$, $\frac{1}{8}''$, $\frac{1}{4}''$, $\frac{1}{2}''$, and 1″, and on the other side in $\frac{1}{12}''$, $\frac{1}{10}''$, etc. The framing square is used as a straight-edge, as shown in Fig. 29, page 16. When used for squaring a board or cross lining the framing square is used as in Fig. 1*a*, page 4.

Graduations on framing square.

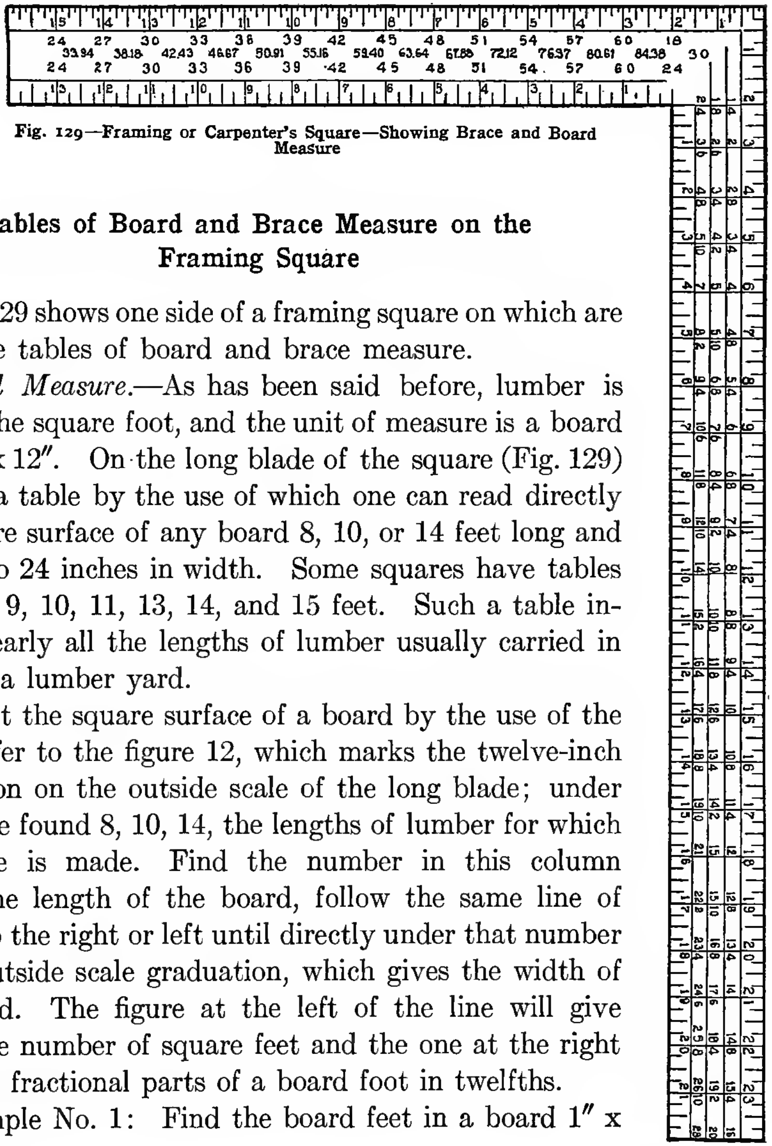


Fig. 129—Framing or Carpenter's Square—Showing Brace and Board Measure

Tables of Board and Brace Measure on the Framing Square

Fig. 129 shows one side of a framing square on which are given the tables of board and brace measure.

Board Measure.—As has been said before, lumber is sold by the square foot, and the unit of measure is a board 1″ x 12″ x 12″. On the long blade of the square (Fig. 129) is given a table by the use of which one can read directly the square surface of any board 8, 10, or 14 feet long and from 2 to 24 inches in width. Some squares have tables giving 8, 9, 10, 11, 13, 14, and 15 feet. Such a table includes nearly all the lengths of lumber usually carried in stock in a lumber yard.

Use of tables of board measure.

To get the square surface of a board by the use of the table, refer to the figure 12, which marks the twelve-inch graduation on the outside scale of the long blade; under 12 will be found 8, 10, 14, the lengths of lumber for which the table is made. Find the number in this column giving the length of the board, follow the same line of figures to the right or left until directly under that number of the outside scale graduation, which gives the width of the board. The figure at the left of the line will give the whole number of square feet and the one at the right gives the fractional parts of a board foot in twelfths.

Example No. 1: Find the board feet in a board 1″ x 4″ x 8′.

Find 8, the length in feet of the board, in the first column under 12 of the outside scale graduation. Follow with the finger the same line of figures until directly under the 4 of the outside scale graduation. We find 2 to the left and 8 to the right of the line. The 2 is board feet and the 8 is $\frac{8}{12}$ of a board foot. The board 1″ x 4″ x 8′ has $2\frac{8}{12}$ board feet.

Example No. 2: How many board feet in a board 1″ x 16″ x 14′?

Under 12 find 14. Follow the same line of figures until under 16 of the outside scale division. We find the board contains $18\frac{8}{12}$ feet.

Example No. 3: Find the board feet in a board 2″ x 4″ x 10′. The table given on the square is for boards one inch thick. A board two inches thick will have twice as many board feet as a board one inch thick. A board three inches thick will have three times as many feet, etc.

Lumber more than one inch thick.

Rule.—For boards that are more or less than one inch thick, find the board feet in the usual way and multiply the table figures by the thickness. It is coming to be the general practice, however, to quote prices for thickness of less than one inch by the square feet in surface, thickness not considered.

Lumber less than one inch thick.

Example No. 4: Find the board feet in a board 1″ x 12″ x 8′.

We can see at once that if a board is twelve inches wide, every foot in length will be a board foot, and the board will have 8 board feet.

Special examples.

Example No. 5: Find the board feet in a board 1″ x 6″ x 12′. Twelve feet is not given in the table, but if we figure the square surface of the board we find that it has six board feet.

A board 1″ x 9″ x 12′ has 9 square feet; and a board 1″ x 17″ x 12′ has 17 square feet. That is, a board 12 feet long has as many square feet as it is inches wide. For this reason the twelve-foot length is not usually given in the table on the square, for the outside scale gradua-

tions are really a table of widths of which 12 is the given length in feet.

Brace Measure.—On the short blade of the square (Fig. 129) will be found numbers $\frac{24}{24}$ $\frac{27}{27}$ $\frac{30}{30}$, etc. These figures give equal distances on two sides of a frame, as *A* and *B*, Fig. 130, while the number immediately to the right of each of these figures gives the corresponding length of the brace *C*.

Use of brace measure.

For example, $\frac{24}{24}$ 33.94 means that if *A* and *B* are each 24 inches long, the brace *C* will be 33.94 inches long. Or if *A* and *B* are each 39 inches the figure to the right of $\frac{39}{39}$, that is, 55.16—gives the length of the brace *C*, etc.

The use of the table is limited to the lengths given, and, with the exception of $\frac{18}{24}$ 30, *A* and *B* are equal.

The Tee Bevel

The bevel (Fig. 131) has a beam (*A*, Fig. 132) corresponding to the beam of the try square, and a blade (*B*) which may be set to any required angle and held in place by the set-screw (*C*). When the bevel is set at any angle it is used the same as the try square. The head is placed against a marked edge and the blade is used as a straight-edge for drawing lines.

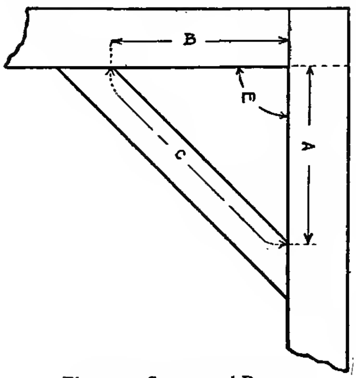


Fig. 130—Corner and Brace

Setting the Bevel

If we wish to get the angle of a brace, as *C*, Fig. 130, and we know the length of *A* and *B*, lay off *A* and *B* on each part of the frame, place the beam of the bevel on either part, and adjust the blade to the extremity of *A* and *B*. If *C* is longer than the blade of

the bevel, place a straight-edge along the line of C and set the blade to the face of it.

If A and B are equal and the angle E is a right angle, the blade may be set to any two points at equal distance from the corner, and the angle of C will be obtained for any length of A and B.

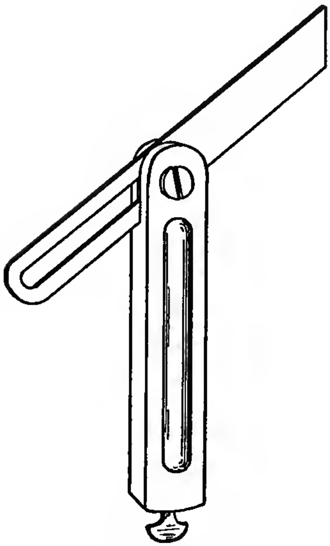


Fig. 131—Tee Bevel

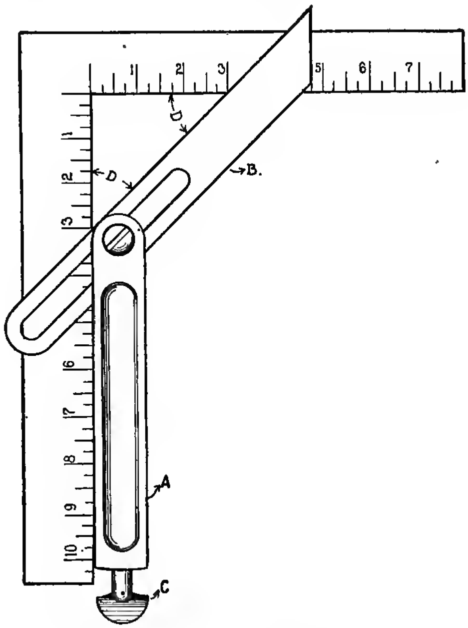


Fig. 132—Setting Bevel to an Angle of 45°

For example, if we wish to get the angle of any or all of the braces given in the table on the square (Fig. 129), except $\frac{18}{24}$ 30, we could place the head of the bevel on either blade of the square and set the blade as in Fig. 132. If the bevel is set in this position and the beam is moved either way on the blade of the square, the blade of the bevel will always mark equal scale divisions on the two blades of the square. The angles D are angles of 45°. Setting bevel to angle of 45°.

To Set the Bevel to 60° and 120°

Compasses.

This will bring into use a new tool, the compasses.* (Fig. 133.) The compasses are used for drawing the circumferences of circles and for spacing off equal measurements. *A* is a set-screw which clamps the leg to the wing (*F*) and holds it in place when set to the required dimensions. To set the compasses place the point on the scale, as in Fig. 134, bring the points as nearly to the scale dimensions as you can, quickly clamp the set-screw, then turn the nut (*B*, Fig. 133) either way as required. This will either draw or release the spring (*C*). The nut and spring are a convenient means of accurate final adjustment.

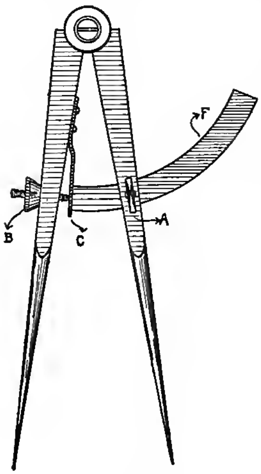


Fig. 133—Compasses

General facts about angles.

Before we can lay out and obtain definite angles we must know certain facts about angles in general. If from any point, as *O*, Fig. 135, we draw 360 lines so as to make all the spaces between the lines, as *A*, *B*, *C*, *D*, *E*, *F*, *G*, etc., equal, then each one of the angles between these lines is an angle of one degree. That is, an angle of one degree is one of 360 equal angles which can be drawn about a point. According to this definition, if we draw a circumference of a circle about the point *O*, Fig. 135*a*, we can measure on that circumference just 360 one-degree angles. Knowing this fact, if we can divide the circumference of a circle into any equal number of parts then we can easily find the number of one-degree angles which may be measured by each part.

Angle of one degree defined.

Circumference of circle used to measure angles.

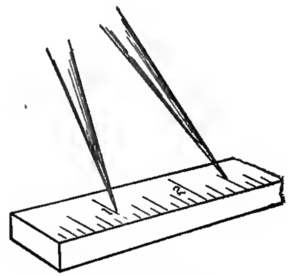


Fig. 134—Setting Compasses to Dimensions

* The large, rather poorly constructed tool used by the carpenter is called the compasses, while the delicate, well-made tool used by the draughtsman is called the dividers.

To measure angles of 60° and 120°.

For example: Draw a circumference of a circle about *O*, Fig. 135*b*; without changing the setting of the compasses space off the circumference just drawn. We find that the circumference of the circle is divided into just six equal divisions. From what we have learned about the one-degree angle we know that through each of these

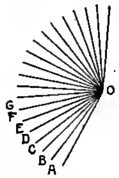


Fig. 135—Laying Out One-Degree Angles About Point O

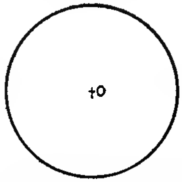


Fig. 135a—360 One-Degree Angles Will Cut the Circumference of any Circle

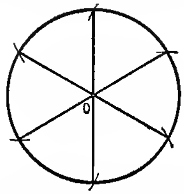


Fig. 135b—Circumference of Circle Used to Measure Angles

divisions $\frac{1}{6}$ of 360, or 60 one-degree angles may be drawn. This knowledge will enable us to lay out almost any angle.

We cannot set the bevel to an angle drawn on paper. But if we joint the edge of a board and with the gauge draw a line parallel with the joint edge, as *A—B*, Fig. 136, we can set the bevel to any angle drawn on the board, having one of the sides parallel to *A—B*.

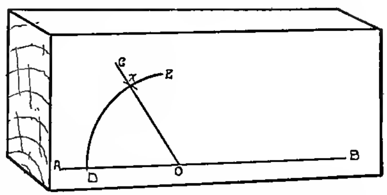


Fig. 136—Laying Out Angles of 60° and 120°

To lay out a 60° angle on the board, with the compasses draw a part of any circumference, as *D—E*; without changing the compasses place one point at *D*, the point where *E—D* cuts *A—B*, and draw a line cutting *E—D*, as at *X*. Through this point (*X*) draw *C—O*. Angle *D—O—C* is an angle of 60°, for, as we have learned, it is $\frac{1}{6}$ of all the one-degree angles that can be drawn about *O*.

It is easy to show that *B—O—C* is an angle of 120°. To set the bevel at 60° place the beam along the edge of the board parallel to *A—O* and set the blade along *C—O*. To set bevel to 120°, place the beam on the edge parallel to *O—B* and the blade along *O—C*.

Cutting or Edge Tools

In the first three chapters of this book we learned that because of the nature of wood it was necessary to have the cutting edge of wood-working tools made to do certain kinds of work. In giving this information it was assumed that the tools at hand were made correctly; but with continued use tools become dull and change their shape. If we examine a number of tools we shall find many shapes and angles that do not seem to embody the principles given. In order to keep tools sharp and give them the best shape for doing any kind of work, it is necessary to know a few of the mechanical facts involved while the tool is performing the cutting operation.

The object of this chapter is to give additional information about tools which will enable the workman not only to select tools but to shape and use them in such a way that they will do the most efficient cutting. A few experiments with a pocket-knife will give us a good understanding of some of the reasons why cutting edges of tools are made and used as they are.

The splitting wedge.

For example, if we start a cut on the end of a piece of wood, as in Fig. 137, the edge of the blade does a little cutting at first, but as the cut advances the wood is split ahead of the edge and the action of the blade is that of the splitting wedge. The only bearing of the wood upon the knife is at A. As a result of this wedging the fibres are torn apart leaving a splintered rough surface. If we start a cut, as in Fig. 137a, and advance into it holding the knife so that the fibres are severed by the cutting edge, the surface (A) will be comparatively smooth and the knife can be made to follow more nearly the required direction.

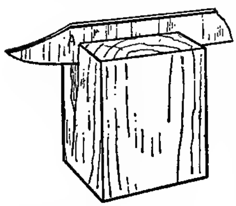


Fig. 137—Knife Used as Splitting Wedge

Obtuse cutting wedge.

Acute cutting wedge.

If the sides of the cutting edge are made long and the angle between them very acute, so that one side of the blade may be held nearly flat

on the surface *A*, Fig. 137*b*, the cut will be made with less exertion, the surface *A* will be much smoother, and the knife may be controlled more easily.

The longer the bearing the blade has on the surface (*A* Fig. 137*b*) the more efficient it is as a cutting tool, providing, of course, that the edge has sufficient strength to withstand the strain. For this reason the chisel is ground only on one side. A few cuts with a sharp chisel will show that it cuts smoother and is much more easily controlled than is the knife.

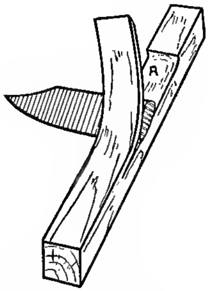


Fig. 137a—Thick, Obtuse Cutting Edge

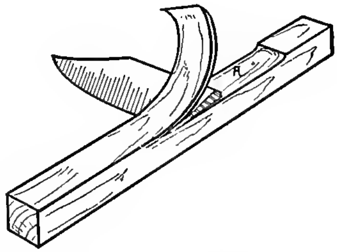


Fig. 137b—Thin, Sharp Cutting Edge

If we place a knife on a piece of wood at right angles to the fibre, as at *A*, Fig. 137*c*, and advance it into the cut to the position *B*, always keeping the knife at the same angle and giving it only a forward motion, it will not cut nearly so well as it will if placed in the position *A*, Fig. 137*d*, and advanced to *B* with a sliding or *shearing* cut. The shearing cut.

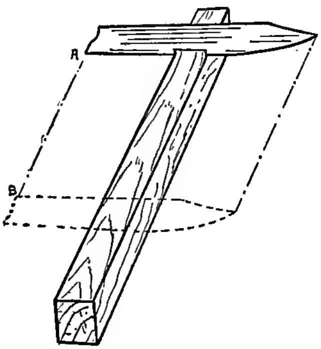


Fig. 137c—Straight Cut

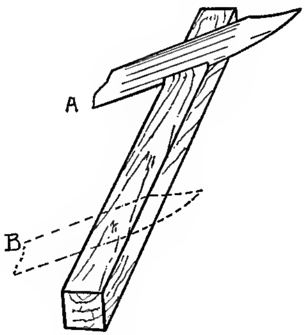


Fig. 137d—Shearing Cut

The paring cut of the chisel, page 43, Fig. 67*c* makes use of this fact.

Cutting across the grain.

For cutting across the grain the knife held as *A*, Fig. 137*e*, is much less efficient than one held as at *B*, the same figure.

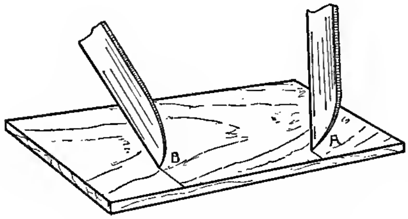


Fig. 137e—Cross-Grain Cutting

By making cuts with the knife at various angles and positions, it will be found that the manipulation of the tool has quite as much to do with the efficiency as does its shape and sharpness. With the above facts in mind, we are ready for a consideration of the edge tools.

The Saw *

We have learned to select the crosscut and the rip saw, and also that for hard and soft wood and for rough and smooth cutting, different shapes and styles of tools are necessary. Saws offer no exception to this general fact.

Saws are catalogued and are spoken of as being a certain number of inches long and as having a given number of teeth or points to the inch. The number of teeth are always one less than the number of points per inch.

Number of teeth and number of points.

Saws with large teeth will cut faster but require more strength to push them. The teeth are weaker and the surface of the cut is rougher than is the case with small teeth. The teeth of the rip saw are usually larger and of a different pitch or angle than those of the corresponding crosscut saw. They generally range from three and one half to eight points to the inch for a 26″ saw, while the crosscut saw teeth range from four to twelve points. Some of the special back saws have as many as sixteen points to the inch.

* Many of the facts about saws given in this chapter are taken from "Disston's Hand Book on Saws." Figs. 137*e*, 143, 143*a*, 144, 144*a*, and 144*b* are copied direct. By permission of Henry Disston & Sons, saw makers.

Set

All saws, with the exception of the very finest back saws, and some special saws, are set—that is, the adjacent teeth are bent in opposite directions in order to make the cut, or kerf, wider than the thickness of the blade. (See Figs. 138, 141, and 142.) The set or bend in the teeth should never extend into the body of the blade for fear of cracking or otherwise weakening it. The saw should always be set before it is sharpened.

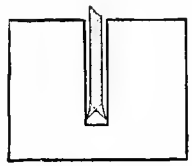


Fig. 138—The Set of the Saw Teeth Makes the Kerf Wider than the Blade

Saw sets.

We find again, as with the other tools, that there are many commercial forms of saw sets, as the tool for setting the saw is called. Figs. 139 and 139*a* show the forms of saw sets generally used by the mechanic who wishes only to keep his own tools in order. A few minutes' actual work with the saw set will be sufficient to give one an understanding of how to operate it, but it takes considerable experience to get the best results.

Filing the Saw

Clamping the saw for filing.

All saws are sharpened by filing. The blade of the saw is made rigid either by clamping in a special vise, as in Fig. 140, or between two boards in the regular bench vise, as in Fig. 140*a*.

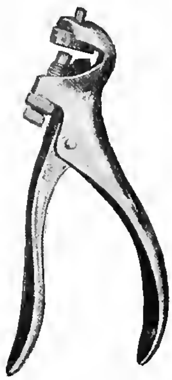


Fig. 139—Saw Set

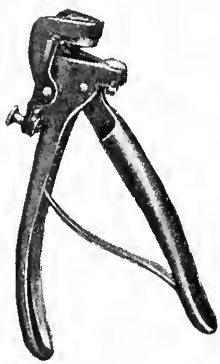


Fig. 139a—Saw Set

The saw must always be held firmly, so that when cutting the file will produce a solid grinding sound. The file that screeches and screams is

merely being worn out and is not doing good work. All saws should be filed from the handle toward the point.

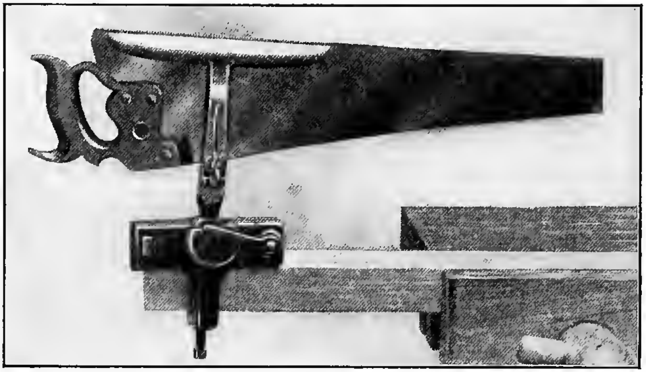


Fig. 140—Special Saw Vise

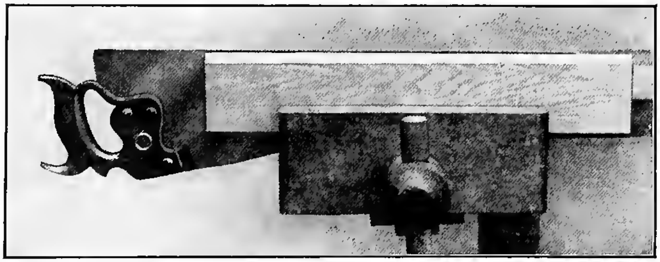


Fig. 140a—Saw Clamped in Bench Vise between Boards

Rip Saw

Filing.

After setting, the teeth of the rip saw are filed square across the blade—that is, at right angles to the blade both horizontally and vertically. If the adjacent teeth are filed from opposite sides, as *C* and *D*, Fig. 141, the cutting edge will be given a slight bevel which will make each tooth cut with a shearing action, thus increasing the ease and efficiency of the cut, as is shown by the experiment with the knife, Fig. 137*d*, page 91.

Fig. 141 is a true mechanical drawing, with the exception that in the plan (*B*) the perspective is added, in order to show more clearly the set in the teeth and the effect of filing from both sides. The angle (*F*, Fig. 141) at the point of the tooth is changed by changing the direction of the line (*G*), the advancing edge of the tooth being always the same. For hard-wood sawing the angle (*F*) is more obtuse and the teeth are smaller than for sawing soft wood.

Filing for hard and soft wood cutting.

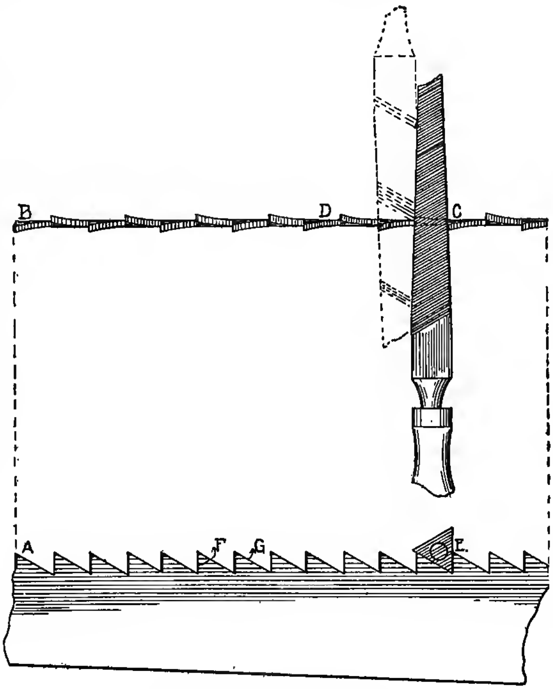


Fig. 141—Filing Rip Saw

The Crosscut Saw

The general shape of the crosscut saw and the reasons for making it as it is are given on pages 5 and 6, Figs. 3, 4, and 5. The adjacent teeth of the crosscut saw are filed from opposite sides. The file is held at right angles to the vertical face and at an angle of about 45° to the horizontal. The angle is measured between the handle of the file and the handle of the saw. In Fig. 142, *A* shows the side elevation and *B* the plan of a crosscut saw. *D* is the file in the horizontal position, while *C* and C^2 are the positions of the file when looked down on from above.

Filing.

Fig. 137*e* illustrates an experiment showing that the advancing

Slant of teeth.

edge of a crosscutting tool is more efficient when it has a certain amount of slant in the direction of the cut. In order to take advantage of that fact the advancing edges of the crosscut saw teeth are made, as a rule, at an angle of about 60°. For example, teeth shaped as in Fig. 143 cut better than those shaped as in Fig. 143*a*. This latter form of tooth strikes the fibre of the wood square at right angles and breaks rather than cuts out the shaving. A saw thus filed is likely to stop quickly in the stroke and either be broken or buckled. There is more strain on the teeth and they will not hold the set or the edge so well. For these reasons the advancing edge of the tooth is seldom changed, but the angle (*B*, Fig 143) is always changed by changing the direction of the line (*C*).

Special shapes of teeth

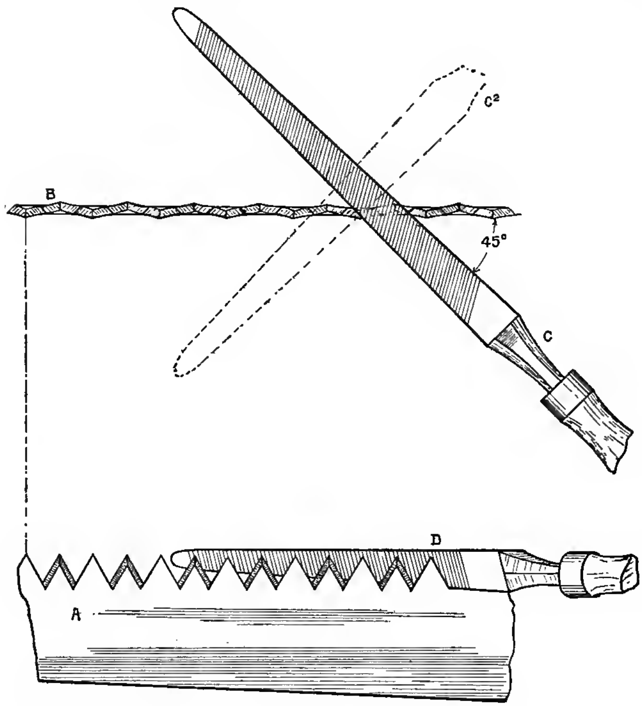


Fig. 142—Filing Crosscut or Hand Saw

Filing for hard and soft wood cutting.

If the points of the saw teeth are too acute they will not stand the strain of hard-wood sawing. Consequently the shapes of the points of the teeth are made according to the work to be done. Figs. 144, 144*a*, and 144*b* are the mechanical drawings of a single tooth, showing the

effect on the shape of the point when the angle of the back face of the tooth (*B*) is changed. A tooth shaped as in Fig. 144, faces *A* and *B* equal, is for soft wood, as in Fig. 144*a*, *B* at an angle less than *A*, is for medium hard-wood and for general cutting, and a tooth

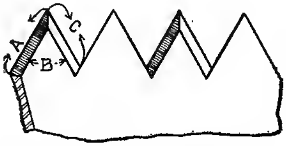


Fig. 143—Usual Shape of Saw Teeth for Crosscutting

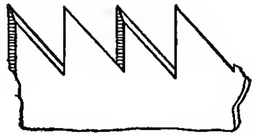


Fig. 143a—Teeth Filed too Straight on Front Face

Fig. 144—Shape of Saw Teeth for Cutting Soft Wood

Fig. 144a—Shape of Saw Teeth for General Cutting

Fig. 144b—Shape of Saw Teeth for Cutting Hard Wood

shaped as in Fig. 144*b* is for hard-wood cutting. The effect on the point of the tooth produced by the change in the angle of the edge (*B*) is easily seen in the drawing.

It will also be noticed that face *A* is the same in each case.

Special Saws

Back Saw.—This saw has been used in the joint work and is shown on page. 40, Fig. 65. The teeth of the back saw are about the same angle as those of a regular crosscut or hand saw, but are much finer.

Miter Saw.—This is simply a long, heavy back saw, as shown in the miter-box (Fig. 145), and is used for very accurate crosscutting. The teeth are not generally set, but the feather-edge left by the file is suffi-

cient to make the kerf of the saw wider than the blade, for the saw is seldom used on any but well-seasoned lumber. The miter saw is held

Miter box.

in a special frame or miter-box. (Fig. 145.) This box holds the saw perfectly true, either square across the piece to be cut or at an angle of 45° either way from the centre. The saw leaves the surface of the wood in such a smooth condition that no further finish is necessary for joining the sawed surfaces.

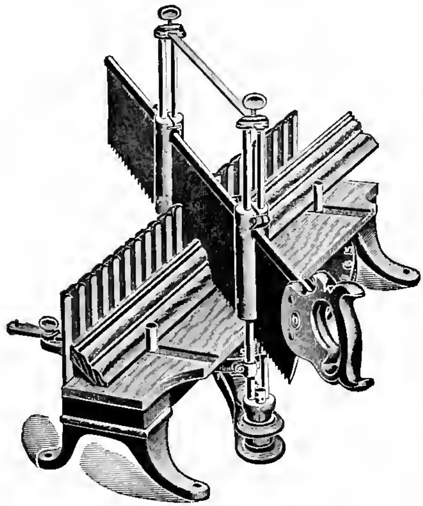


Fig. 145—Miter Saw and Box

Compass saw.

The compass saw (Fig. 146),

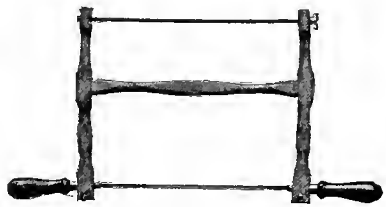


Fig. 146a—Turning or Web Saw

Fig. 146—Compass Saw

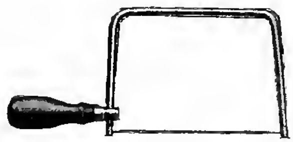


Fig. 146b—Coping Saw

Turning or web saw. Coping saw.

the turning or web saw (Fig. 146*a*), and the coping saw (Fig. 146*b*), are all made for cutting to curved lines and for special cuts where the other

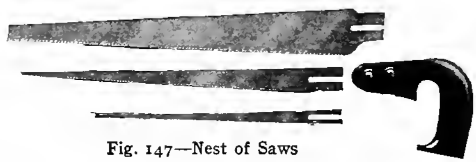


Fig. 147—Nest of Saws

saws will not work because of their size and shape. Fig. 147 shows a

Key-hole saw.

nest of saws which fit the same handle; the smaller blades of the set are used as compass and key-hole saws.

Selecting a Saw

In selecting a saw care should be taken to choose one that is well hung—that is, one which is in good balance. The handle should fit the hand, and when making a cut it should be easy to hold to the line. Spring the blade and see that it bends evenly in proportion to the width from the tip to the butt. The thinner the blade the better, if it is stiff enough to stand the strain of cutting. A new saw should be well set and sharpened, and one should always take a cut with it before buying.

Planes

Sharpening.

The parts and the use of.

The planes most used have been considered at some length on pages 8 to 10, Figs. 7 to 13, inclusive, and grinding and oil-stoning, pages 12 and 13, Figs. 15 to 20. The parts of the plane, their use, and their adjustment were considered on pages 13 to 15, Figs. 21 to 26.

Special Planes

Universal planes.

The wood-worker of a few years ago who did anything more than the most common work had to have a whole set of special planes, con-

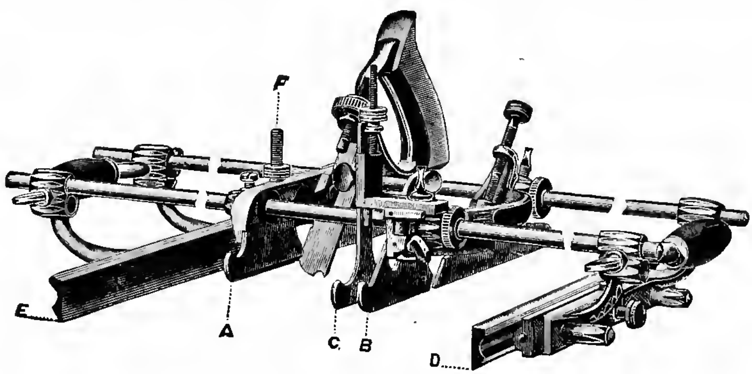


Fig. 148—Universal Plane

sisting of rounds, hollows, beading, rabbeting, matching, and many others. Planes have been improved so much recently, however, that a single plane stock provided with special cutters will take the place of all the others. Such a plane is called a universal plane and is shown

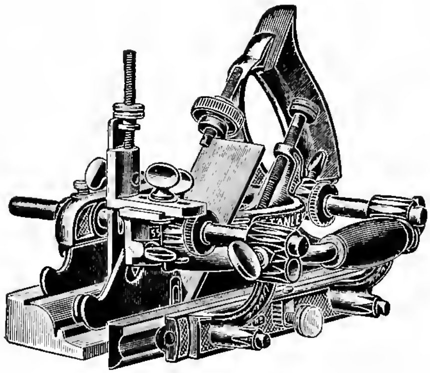


Fig. 148a—Universal Plane Set to Cut Moulding

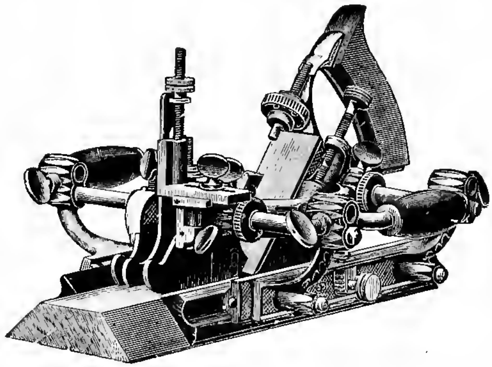


Fig. 148b—Universal Plane, Special Setting

in Figs. 148, 148*a*, 148*b*. The figures show the same plane set for different operations.

The above universal plane is very elaborate, probably too elaborate for ordinary use; but planes may be obtained for doing any one or any group of operations, such as hollows, rounds, matching, rabbeting, etc.

Universal and special planes are always accompanied with full directions for adjusting and using, which are much better than can be given here.

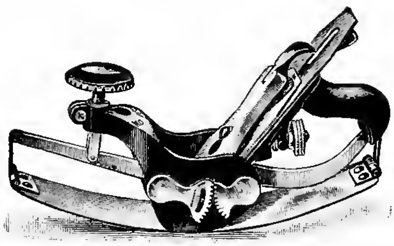


Fig. 149—Circular Plane

Circular plane.

The Circular Plane (Fig. 149) is a plane with a thin steel base, which may be made concave or convex, to work on either a concave or a convex surface.

The spokeshaves, two types of which are shown in Figs. 150 and 151, are in reality planes, but are not generally considered as such. As is shown in the cuts, the bits are set in a very short stock, which enables them to cut on an irregular surface. Fig. 150 shows a tool with a screw adjustment for depth of cut. Spokeshave.

Fig. 150—Spokeshave

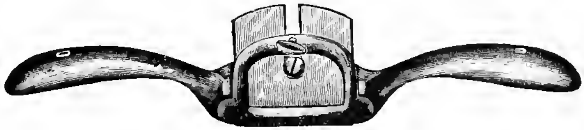


Fig. 151—Spokeshave

The Router Plane, one form of which is shown in Fig. 152, is convenient for cutting or smoothing the bottom of a gain or groove. Such planes are used a great deal for cutting out equal depths of stock for inlaying—that is, for setting in pieces of wood of different kinds from the one with which we are working. A good example is parquetry flooring.

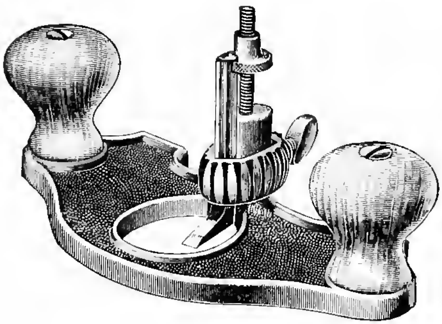


Fig. 152—Router Plane

Special planes are made for almost every kind of work. Reference to a dealers' catalogue will usually give the desired information about any plane needed.

Chisels

Chisels are listed or catalogued according to their size and length. The size of chisels. As stated before, the size of a chisel is designated by the width of the cutting edge, and ranges from one eighth inch to one inch, by eighth inches, as $\frac{1}{8}''$, $\frac{1}{4}''$, $\frac{3}{8}''$, $\frac{1}{2}''$, etc., and from one to two inches, by quarter inches.

Tang and socket chisels.

Chisels are called tang or socket chisels, according to the way in which the handles are fastened to the blades. The tang chisel has an end which fits into the handle, as in Fig. 153. The socket chisel has an end into which the handle fits, as in Fig. 154.

Fig. 153—Tang Chisel

Square and bevelled edge chisels.

Both the tang and the socket chisels are manufactured with blades having square edges, as in Figs. 153 and 154, or with bevelled edges, as in Figs. 155 and 156. The bevelled edge chisel presents the better appearance, seems to be hung better—that is, to have the better balance—and is more easily ground and oilstoned, because it has less grinding surface on account of the corners having been cut away. The bevelled edge chisel costs a little more than the square edge.

Fig. 154—Socket Chisel

Types of chisels.

Paring, Firmer, and Framing Chisels.—According to their use, chisels are designated as paring, firmer, and framing chisels. The paring chisel is a large, thin-bladed chisel used mostly for light work, and should not be driven into the cut by a mallet. The firmer chisel is somewhat heavier and shorter than the paring chisel and is driven into its cut by a mallet on light work. The framing chisel is a short, heavy chisel made to stand driving with a mallet, and for this reason the handle is usually protected by a ferrule, as is the handle of Fig. 160.

Fig. 155—Tang Chisel with Bevelled Edge

Fig. 156—Socket Chisel with Bevelled Edge

All three of the above-mentioned chisels are made either with square or bevelled edges and with tang or socket for holding the handle, although the tang does not hold the

handle of the chisel as well as the socket. All chisels are ground and oil-stoned the same as the plane bit (pages 12 and 13, Figs. 16 to 20, inclusive). For test of sharpness, put a piece of soft wood in the vise and cut it across the grain. As stated in the second chapter, the cut should be smooth.

Sharpening chisels and a test for sharpness.

Special cuts and operations with chisels have been considered as follows: Chiselling end of lap joint, page 42, Fig. 67. Paring cut, page 43, Fig. 67*c*. Bevelling to line, page 43, Fig. 67*b*. Chiselling mortise, pages 51 to 55, Figs. 70*e* to 70*l*, inclusive.

Special cuts and operations.

All chisels are ground with more or less bevel at the cutting edge, according to the nature of the material they are to cut and the kind of work to be done.

Gouges

Gouges (Figs. 157 and 158) are chisels the blades of which are curved. They are designated as tang, socket, paring, firmer, and framing gouges, the same as are the flat chisels.

If the gouge is ground on the outside (Fig. 158)—that is, on the convex surface—it is called an outside-ground gouge. If ground on the inside, or concave surface (Fig. 157), it is called an inside-ground gouge.

Outside and inside ground gouges.

Fig. 157—Inside-Ground Gouge

The size of the gouge is the length of a straight line across the corners of the cutting edge, and ranges from one-eighth of an inch to one inch, by eighths of an inch, and from one to two inches, by quarter inches.

Size of gouges.

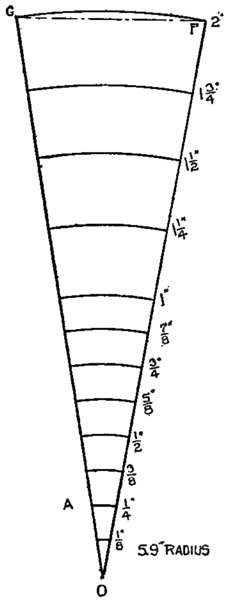
Fig. 158—Outside-Ground Gouge

The curvature of the blade of a gouge is called the sweep, and sets of gouges are made in three sweeps—*flat sweep*, *middle sweep*, and *full* or *quick sweep*. For the flat sweep it takes eighteen gouges

Sweep of gouges.

of any size to complete a circle. For the middle sweep it takes six, and for the full or quick sweep it takes three. This is theoretical. The gouges will, in reality, vary slightly from this owing to the difficulty of getting them correct.* But they will be near enough so that the following diagrams (*A*, *B*, *C*, Fig. 159) may be used to obtain approximately the size and shape of any gouge in any set. For example, to obtain the shape and size of a gouge in the flat sweep with *O* as a centre (*A*, Fig. 159), and a radius 5.9″ long, draw an arc, as *G*—*F*, so that the chord of the arc will be 2″; the arc will be the shape or curvature and the chord will be the size of the two-inch flat sweep gouge. If we measure down the radii *O*—*G* and *O*—*F* to the points where they are $1\frac{3}{4}''$ apart, and, with *O* as a centre, draw another arc through the points, the arc will be the shape and the chord will be the size of the $1\frac{3}{4}''$ gouge. In the same way, with *O* as a centre, we can draw an arc at the points where the radii *O*—*F* and *O*—*G* are $1\frac{1}{2}''$, $1\frac{1}{4}''$, $1''$, $\frac{7}{8}''$, etc., apart and thus obtain the curvature and size of all gouges in the set.

To obtain any sweep.



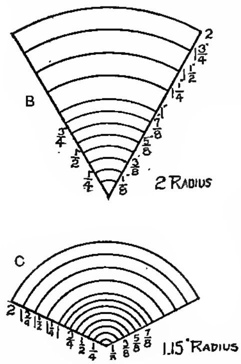


Fig. 159—Cuts Show Method for Getting Sweep of Gouge

For the middle sweep, proceed the same way, only the first radius will be 2″ long, and for the full or quick sweep the first radius will be 1.15″ long.

As stated above, these measurements are only approximate, but are close enough to give valuable aid in ordering gouges.

* Information obtained from Mack & Co., Rochester, New York, tool makers.

Corner Chisels

A corner chisel (Fig. 160) is a chisel with the blade made in such a way as to form a right angle. It is convenient for cutting corners in mortises and similar openings.

Fig. 160—Corner Chisel

Auger Bits

The form of the auger bit in most common use is shown in Fig 161. Such bits usually come in sets of thirteen, ranging in size from one-quarter to one inch, by sixteenths—that is, $\frac{1}{4}''$, $\frac{5}{16}''$, $\frac{3}{8}''$, $\frac{7}{16}''$, $\frac{1}{2}''$, etc. The size of the bit is the size of the hole that it bores, and is marked on the shank (*b*, Fig. 161) as 4, 5, 6, 7, 8, etc., meaning $\frac{4}{16}''$, $\frac{5}{16}''$, $\frac{6}{16}''$, $\frac{7}{16}''$, $\frac{8}{16}''$, etc. Bits for boring holes larger than one inch may be obtained; but an expansive bit (Fig. 162) is a very efficient tool with wider range of usefulness and will cost much less than sets of bits over one inch of the type shown in Fig. 161. The cutter (*a*) of the expansive bit shown in Fig. 162 may be adjusted and held in any position by the screw, thus regulating the size of the hole to be bored. The expansive bit is usually made in two sizes, the smaller size boring holes from $\frac{5}{8}''$ to $1\frac{3}{4}''$, and the larger size from $\frac{7}{8}''$ to $3''$. Each size is provided with two lengths of cutters.

Size of auger bits.

Fig. 161—Common Auger Bit

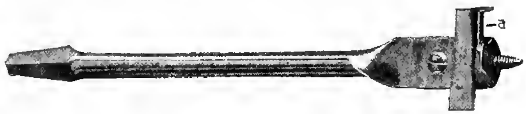


Fig. 162—Expansive Bit

Expansive bits.

The Irwin Bit.—In recent years the form of bit shown in Fig. 161

Solid centre stem bits.

has been much improved upon by the type shown in Fig. 163. The chief feature in the added efficiency of this bit is that the single twist offers less resistance to the shavings by giving more room for them to carry up out of the hole. These bits are known under the trade name of "The Irwin Car Bit," or the solid centre stem bit and range in size the same as the other bits.

Fig. 163—Irwin Solid Centre Stem Bit

To Sharpen an Auger Bit

Nibs. Auger bits are sharpened by filing. The nibs (*a* and *b*, Fig. 161), are always filed on the inside. To file them on the outside would decrease the diameter of the bit at the point and thus the diameter of the hole, which in turn would prevent the bit from entering the wood. The lips—that is, the cutting edges—are filed on the under surface, the edge being made the shape of a chisel. The screw (*c*) at the centre of the bit, which draws it into the wood, is called the spur. Spur. Care should be taken not to injure the spur, for the efficiency of the bit depends upon it.

Special Bits

The larger dealers carry in stock a variety of bits suitable for almost any form of work. A few special types are given below.

Fostner Bit.—The Fostner bit, shown in Fig. 164, is a bit made without the spur. It leaves the bottom of the hole flat, a great advantage in some holes that are not to be bored entirely through. Another feature is that the bit will cut with any portion of the face overlapping an edge, as shown in Fig. 165. This is a convenience in removing the stock from a mortise or any other recess in the wood.

Fig. 164—Fostner Bit

Size of gimlet bits.

Gimlet Bit.—The gimlet bit (Fig. 166) is made in sizes ranging from $\frac{2}{32}''$ to $\frac{12}{32}''$, by a difference in size of $\frac{1}{32}''$. This type of bit is good for boring small holes; but in boring into small pieces one must be careful not to split the wood. The tapering end, unless very sharp, wedges its way into the bore, and tends to split the piece.

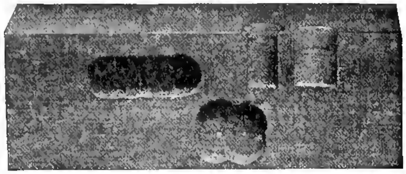


Fig. 165—Special Cuts with Fostner Bit

Another and generally speaking a better type of gimlet bit is shown in Fig. 167. This form of bit is not so likely to split the wood and is much easier to sharpen. It ranges in size the same as the other gimlet bits.

Fig. 166—German Gimlet Bit

Fig. 167—Morse Gimlet Bit

Twist drill.

Fig. 168 shows a twist drill. While it is made for boring metal, it is very convenient for boring small holes in wood. It has the advantage of being stronger and giving a wider range of sizes than the regular gimlet bits. It ranges in size from No. 1 to No. 60. No. 1 is a little smaller than one-quarter inch, while No. 60 is too small for any form of wood-work. The successive sizes vary by a small fraction of an inch. Any of the braces described below will hold a twist drill not less than one-quarter inch in diameter. For smaller diameter a brace like the one shown in Fig. 169*b* is used.

Fig. 168—Morse Twist Drill

Bit Braces

All of the bits mentioned above are driven to their work by means of a brace, the most general form of which is shown in Fig. 169, though there are many modifications of this simple form.

Ratchet-Brace

Fig. 169*a* shows a ratchet-brace. The ratchet which is placed at *a* is an arrangement which enables one to drive a bit where it is not possible to make a complete revolution of the brace. This result is accomplished by means of two dogs or pawls, which may be made to

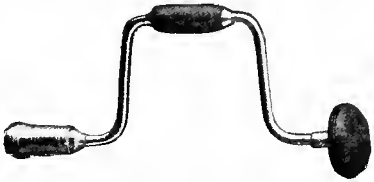


Fig. 169—Plane Brace

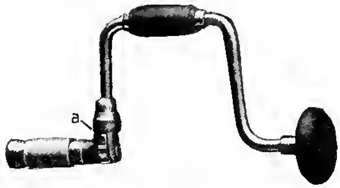


Fig. 169a—Ratchet-Brace

catch in a notched wheel. When both pawls are resting in the notches the brace works the same as the simple brace. (Fig. 169.) By turning a collar at *a* one or the other of the dogs may be raised and held out of the notch. If we wish to drive a bit into a corner where the brace will not make a complete turn, one pawl may be left in the notch and the other raised. A forward motion of the brace drives the bit. A backward motion leaves the bit stationary, while the pawl, which is in the notches, slips back and takes its place in another notch ready to drive the bit forward on the forward stroke. The usefulness of such a brace is self-evident.

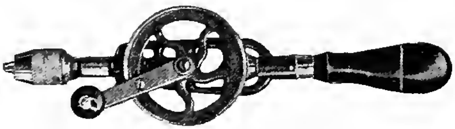


Fig. 169b—Breast Drill

Universal Angular Brace

Fig. 170 shows a universal angular brace. This brace is for boring into corners or at any angle.

Bit Stop

A, Fig. 171, shows a convenient stop attachment for any size bit. By means of the clamping screw (*B*) the attachment may be clamped in any position on the shank of the bit. This enables the workman to bore a hole, or any number of holes, to any required depth.

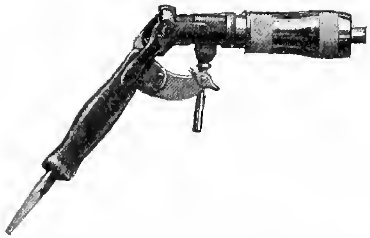


Fig. 170—Universal Angular Brace

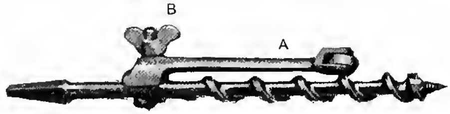


Fig. 171—Bit Stop Attached to Bit

Miscellaneous Tools

The draw-knife (Fig. 172) is in reality a chisel, though not usually classed as such. The blade is sharpened flat on one side like the chisel, while the handles are made for pulling rather than for driving or pushing. The draw-knife is used for rather rough modelling and for cutting to a straight line when the cut is made on the edge of the board.

Fig. 172—Draw-Knife

Hammer.—The hammer, its use and construction, have been considered on page 70, Figs. 112*a* and *b*, and Fig. 113.

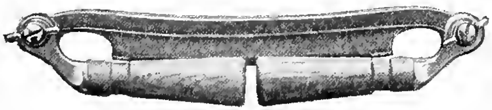


Fig. 172a—Draw-Knife, Handles Down to Protect Cutting Edge

Nail Set.—For nail set, see page 71, Fig. 114.

Screw-Driver.—For screw-driver, see page 74, Fig. 121.

Screw Countersink.—For screw countersink, see page 73, Fig. 119.

Grindstone.—The use of the grindstone, for grinding edge tools, has been considered on page 12, Fig. 16. As is stated, *a* represents the tool, *b* the stone, and the arrow the direction in which the stone is turning. The relation between the direction of the stone and the cutting edge of the tool is usually as stated, but for beginners it is safer to put the tool on the other side, where there is no danger of its catching.

The grindstone for wood-working tools should be medium soft and coarse. This will cut fast and give a reasonably good surface to the cutting edge of the tool. Water should always be used on a grindstone to wash out the crumbled parts of the stone and metal. If the surface of the stone becomes gummed or out of shape it must be dressed. A convenient method of dressing a stone is to use a gas-pipe over a rest the same as a turning tool. There are several forms of commercial stone-dressers which are easy to use. However, stone-dressing should be done by the older workmen.

Dressing the grindstone.

Oil-Stone.—All grinding on the grindstone should be followed by whetting on an oil-stone. The principle of whetting has been given on pages 12 and 13, Figs. 18, 19 and 20.

Washita and Arkansas stones.

The best oil-stones are known as the Washita and the Arkansas stones. These are natural stones quarried and cut to the required shapes. The stone is hard, with a very fine grit, which gives an unusually fine edge to the tool. For ordinary wood-working it is not necessary to have so fine or so expensive a stone.

India Oil-Stone.—"India Oil-Stone" is the trade name given to an oil-stone manufactured in the United States. It is made of emery held together by a cement. This stone is very efficient and is reasonable in price.

Oil for stone.

When in use, the surface of the oil-stone should be covered with a thin layer of the best grade of lubricating oil—not the heavy cylinder

oil, but a thin oil without much gum. One should always guard against the use of too much oil, for the dirty oil-stone is the worst source of grime around a bench.

Oil-stones are made in many shapes and sizes. The two sizes and shapes in most constant use, however, are given in Figs. 173 and 174.

Fig. 173—Common Shape for Bench Oil-Stone

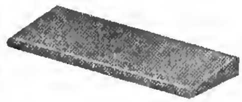


Fig. 174—Oil-Stone Slip

To true the face of an oil-stone, rub it over a flat piece of No. $1\frac{1}{2}$ sand-paper. To true the oil-stone.

Oil-Can.—All shops should be provided with a sufficient number of oil-cans.

CHAPTER VI

WOOD FINISHING

Wood finishing is a trade all by itself. It is seldom that the workman who does the wood-work does the finishing also. It will, therefore, be the object of this chapter to give only enough about wood finishing to enable the amateur to finish well the articles of wood-work spoken of in this volume and similar articles which these may suggest to him.

The Objects of Wood Finishing

Wood must be seasoned.

The first and real object of wood finishing is to protect the wood from moisture, dirt, and weather. All wood should be well dried or seasoned, as the drying process is called, before it is used in any kind of construction. But, no matter how well it is seasoned, if moisture comes in contact with the wood it will be absorbed, the wood will expand, and when the moisture again dries out the wood will contract. If this expansion and contraction takes place at all it will cause cracking and weakening, and if continued it will cause a general letting go of all the joints to the utter ruin of the article of wood-work. If dirt of any kind comes in contact with the unprotected surface, the wood is at once covered with a grime that cannot be cleaned off. Consequently it will be seen that, the first object of finishing is to protect the wood.

Another object of wood finish, and indeed of almost as much importance as the one just mentioned, is to add beauty to the manufactured article. Any really good wood finish will meet both requirements.

Painting and Hard-Wood Finishing

Painting protects the wood by covering it with a coating of material which conceals the surface entirely and has come to be used almost entirely on work which must withstand the elements. The beauty of painted wood-work is all in the paint.

Hard-wood finishing is a term used to designate the form of wood finishing generally used on interior house work, cabinet work, etc. Unlike painting, this form of wood finishing seeks to bring out the natural beauty of the wood, and by the use of transparent coverings, such as varnish, shellac, waxes, oils, etc., seeks also to protect the wood. This latter form of wood finishing is of most concern to the amateur, and therefore will be considered first.

Hard-Wood Finishing

Condition of surface.

The first and most important requirement in hard-wood finishing is that the surface of the wood be put in proper condition to receive the finish. This means that the surface must be free from all defects, such as scratches, nail-holes, shaky knots, irregularities in the surface, and many others, which experience will teach us to observe.

To obtain the required surface on the wood, great care should be

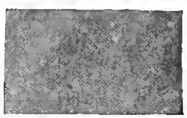


Fig. 175—Plain Straight-Edge Scraper

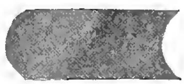


Fig. 175a—Concave and Convex Scraper

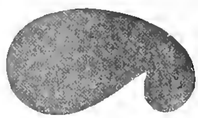


Fig. 175b—Swan-Neck Scraper

Plane the surface.

taken. First, a very sharp, smooth plane should be run over the whole surface and, so far as possible, all defects should be removed. In case of knots or cross grain, where the plane will not work well, a scraper is

used. The scraper is a thin piece of saw steel of convenient size to manipulate well. Figs. 175, 175*a*, and 175*b* show the forms most used.

The Scraper and Its Use

The scraper, though a useful tool, is likely to be pressed into service too freely by an amateur. Any attempt to remove a considerable amount of stock with a scraper will result in failure, so far as finish is concerned, for it is impossible to guide the scraper in such a way as entirely to prevent inequalities in the surface which mar the finish. The scraper is, however, a very efficient tool if properly used, and is indispensable in all forms of cabinet work. To do effective work, the scraper must be sharp. The sharpening of a scraper is learned only by experience. A few suggestions are offered, however, in order to give the beginners a start. The shape of the cutting edge of a scraper should be ground to meet the requirements of the surface to be scraped. Flat scraper. For flat surfaces, use a scraper as in Fig. 175; Convex and concave scraper. for convex and concave surfaces, use one as in Fig. 175*a*, while for mouldings and various parts of irregular curves, the swan-neck scraper is to Swan-neck. be used (Fig. 175*b*). The entire edge of the swan-neck is sharpened, and when scraping the part of the edge which most nearly fits the surface should be used.

Fig. 176—Making Straight Edge on Scraper

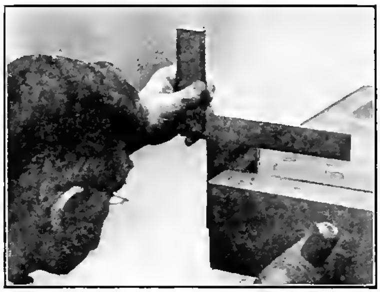


Fig. 176a—Testing Edge of Scraper with Try Square

To Sharpen the Scraper

The irregular-shaped scrapers can seldom be sharpened by grinding, because of the shapes, and the amateur will find it difficult to grind even the straight-edge scraper. When one has sufficient skill to grind the ordinary tools properly, scraper-grinding will solve itself. In the meantime filing is probably the best way for a beginner to sharpen a scraper.

Filing the scraper.

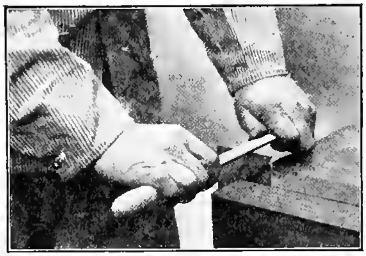


Fig. 176b—Draw-Filing Scraper

Sharpening straight-edge scraper.

To sharpen a straight-edge scraper, place it in the vise and, with a fine file, file the edge straight, as is shown in Fig. 176. To make sure that the edge is straight, test it with the blade of the try square, as in Fig. 176*a*. The edge of the scraper should also be square with the face. When the edge is straight and square, place the file across it as in Fig. 176*b*, and pass the file from end to end two or three times. This is called draw-filing. After this operation a very fine burr will be found on each edge. Remove the scraper from the vise and oil-stone it flat on each side, as in Fig. 176*c*. Then oil-stone it square on the edge, as in Fig. 176*d*. When the edges are sharp and square, replace the scraper in the vise, and with a screw-driver or gouge, or, what is still better, a butcher's steel, turn a sharp burr by passing the steel across the edges with considerable pressure. (Fig. 176*e*.) This burr forms the cutting edge.

Draw-filing.

Oil-stoning.

Turning the edge.

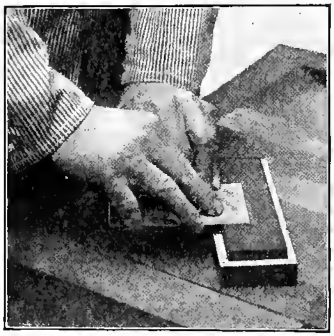


Fig. 176c—Oil-Stoning Flat Side of Scraper to Remove Feather-Edge

When the scraper is but slightly dulled the last operation is all that is required to renew the edge. A little practice will enable one to

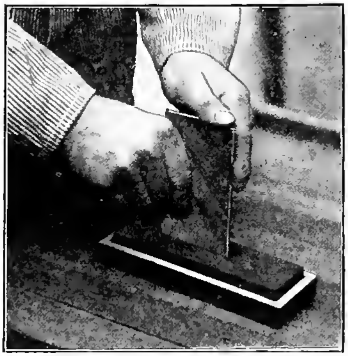


Fig 176d—Oil-Stoning Edge of Scraper to Make Sharp, Square Corners

Fig. 176e—Turning Edge of Scraper with Butcher's Steel

sharpen a scraper so that it will cut a good, clean shaving, rather than merely scrape, as its name might indicate.

How to Use the Scraper

Position of scraper.

To make a cut with the scraper, grip it in both hands and place it on the wood with a slant in the direction of the cut. (Fig. 177.) The slant should be sufficient to make the burr, which was made in sharpening, grip the wood and cut a shaving on the forward stroke of the scraper. When the exact position or slant is found it must be carefully maintained throughout the entire stroke, for, like other tools, the cutting edge of the scraper must be held into the cut.

Fig. 177—Correct Way of Holding Scraper

The tendency among beginners is to rock the scraper—that is, to start it at the proper slant, as at *B*, Fig. 177*a*, and constantly change the slant through the entire cut and end as at *C*, Fig. 177*a*. Such use of the scraper is of no avail. It should be held rigidly on the cutting edge throughout the entire stroke. It may be pushed or pulled, the only requirement being that it be held properly. A piece of old sand-paper laid over the face of the scraper, with the sand down, will give a good grip and prevent burning the fingers. Rocking the scraper.

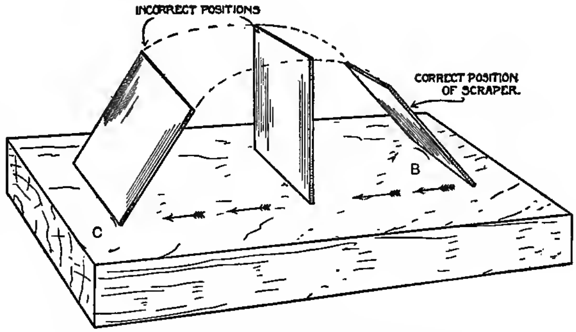


Fig. 177a—Correct and Incorrect Positions of Scraper

Sand-Papering

When we are sure that it will not be necessary to do any more cutting with edge tools, and not until then, we can use sand-paper to finish a piece of wood. The grit left in the pores of the wood by the sand-paper will take the edge off the tool almost as effectively as will a grindstone. When sand-paper is used it should be treated as a tool, which it really is, and should be handled just as carefully. When to use sand-paper.

Sand-paper is numbered according to the size of the grains of sand used on the surface. The numbers begin with 00 (double nought), which is the smallest, and range as follows: 00, 0, $\frac{1}{2}$, 1, $1\frac{1}{2}$, 2, $2\frac{1}{2}$, 3. Commercial packages of sand-paper contain one ream, in sheets 9″ x 11″, though most dealers sell any number of sheets desired. Size of sand-paper.

How to Use Sand-Paper

For the first sanding of a piece of lumber the coarse sand-paper is used, though it is seldom necessary to use Nos. $2\frac{1}{2}$ and 3, for they leave such deep scratches that it takes a great deal of sanding with finer paper to remove them.

Sand-paper held under the hand.

If sand-paper is held under the hand, as in Fig. 178, it will follow the exact shape of the surface. If we attempt to sand-paper on or near an edge, it will drag the corners and spoil the neat, sharp lines by making them rounding; and if we examine the surface of the paper we shall find that most, if not all of the cutting has been done by the spots upon which the fingers or the parts of the hand rested. This means a waste of paper and time as well as a poor piece of work. To overcome all of the above difficulties the sand-paper block, as shown in Fig. 179, is used.

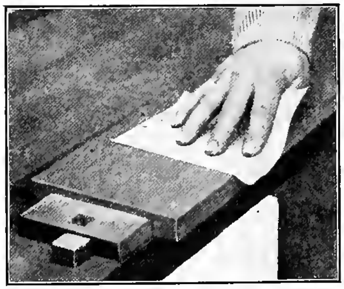


Fig. 178—Incorrect Way of Holding Sand-Paper

Sand-paper block.

The sand-paper is cut into strips and drawn over the sharp edges of the block, as in Fig. 180. The sharp edges prevent the paper from slipping. The face of the block, over which the paper is drawn, should be perfectly straight, flat, and smooth, so that every part of the paper will come in contact with the surface of the wood. Sand-paper thus held will not follow the small depressions in the surface, but will cut only on the high spots, gradually bringing them level. The paper cannot drag the edges because it is held up by the block. In fact, the block gives one perfect control of the cutting of the sand-paper and

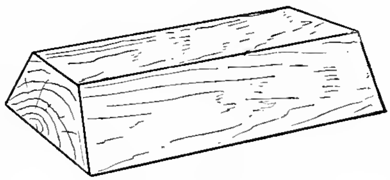


Fig. 179—Sand-Paper Block

makes it an efficient tool. The paper, however, should never be tacked or nailed to the block, for it is necessary to renew it often and tacking takes too much time, besides spoiling the block.

Sand-paper with the grain.

In general, sand-papering should be done parallel to the grain of the wood, and, indeed, carefully so. Careless cross-grain strokes with the paper will cause scratches, which show plainly when the wood is finished, and the better the finish the more they show. A tendency of the beginner is to stand at one side of the piece to be sanded and pass the paper across and back in front of him in moon-shaped curves. Such sanding leaves a scratchy, bad surface. The sand-paper should always be *pushed straight forward* and *pulled straight back*. Great care must be taken when cross and straight grain pieces come together—as, for example, the corners of a picture frame—that the stroke be not carried over from the straight to the cross grain.

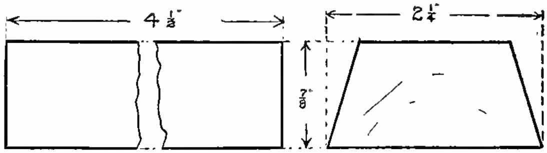


Fig. 179a—Mechanical Drawing of Sand-Paper Block


Fig. 180—Sand-Paper Held on Block

Sand-papering round edges.

To make a round edge on a piece of wood, or to round a box corner, as in Fig. 126*a*, page 82, shape it as nearly round as possible with the plane, then hold it in the vise and draw a piece of sand-paper back and forth across the edge, as in Fig. 181. The final sanding, however, should be done with the grain, as before stated.

Much more might be said about sand-papering. More elaborate blocks for holding the paper are often made, and many other devices are often resorted to. But a little experience will serve to call attention to the foregoing fact as well as to suggest many additional ones.

Selection of Finishing Materials

When the surface of the wood is in proper condition to receive the stains and varnishes, the selection of these materials is a matter of considerable importance. Suitable material can be selected only when the workman knows all the surrounding conditions of use. It will, therefore, be possible to give only a few general principles of wood finishing, and the wood-worker must make the application to the work in hand. A general statement of the steps in wood finishing may be made as follows:

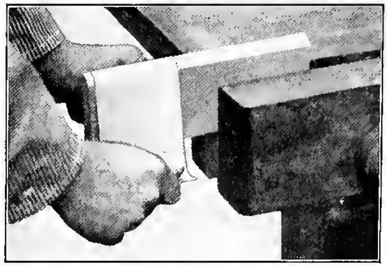


Fig. 181—Rounding an Edge with Sand-Paper

Necessary steps in wood finishing.

1. Preparation of the wood to receive the finish.

2. Decide color of finish, and if it is not to be the original color of the wood, select suitable stains or colors and apply to the wood.

3. Note carefully the texture of the wood. If the fibres are close together and the pores are so small that they cannot be seen with the unaided eye, then the final finish may be applied at once. If, however, the fibres are coarse and the pores are large, it will be necessary to fill them with some substance which will make them level with the surface of the wood and prevent the finishing material from being absorbed into the wood. This method of closing the pores is called wood filling.

4. The application of the final finishing materials.

The first step in the process of wood finishing given above has been considered, and, as was stated, it belongs properly to the work of the cabinet maker; but inasmuch as this step includes the place where the cabinet maker lets go and the finishing begins, the subject has been given a middle place.

Wood Staining and Coloring

The second step in the process of wood finishing, that of staining and coloring, is one that has recently taken on great variety, and many very beautiful tones and shades have been produced. On the other hand, almost anything painted, smeared, or daubed over the surface of the wood will change the appearance, and some one can always be found who will call it beautiful. The object of the best finishers is, however, to bring out the natural beauty of the wood rather than to add mere color as striking effect. To do this the coloring matter must be as nearly transparent as is possible to make it. Nearly every color manufacturer has a special make of colors prepared ready for use which are claimed to possess all the virtues and none of the faults of such materials. In general, however, coloring materials may be classified as follows:

Object of best wood finishers.

1. Oil stains—that is, color pigments dissolved in oil: linseed oil, benzine, naphtha, and turpentine, etc.
2. Spirit stains—that is, colors, generally aniline, dissolved in spirits, usually alcohol.
3. Water stains—that is, colors of any kind dissolved in water.

Oil Stains

Oil stains made of pigments dissolved or ground in linseed-oil are more like paints than like stains. They are easily made and easily applied to the wood. They do not raise the grain of the wood, as do the spirit or water stains. There are, however, several objections to them. The first and great objection is that they are so opaque that they cover the natural beauty of the wood. Another objection is that they do not penetrate the wood deeply and any scratching or marring of the surface reveals the unstained wood beneath. Any defacement is very hard to remove. About the only remedy is to remove all the

Objections to fat-oil stains.

finish from the surface and refinish; but even then in the end we have the same opaque coloring for the wood.

Volatile oil stains.

Stains made of the light volatile oils, such as naphtha, benzine, etc., are almost wholly different from those made from the heavy oils. They spread over the surface easily, adhere to the wood, penetrate deeply without raising the grain, and are very transparent if wiped off with a cloth or a piece of waste while the stain is still wet.

Spirit Stains

Spirit stains are usually made of aniline color dissolved in alcohol. They are easily made. All that is necessary is to mix the required color in alcohol until the desired shade is obtained. The spirit stains are easily applied, are transparent, and penetrate the wood deeply. But on the whole they are so little better than the water stains that it does not pay to use them, because of the difference in cost, which is the difference between the cost of alcohol and water. Spirit stains are applied the same as are the water stains.

Water Stains

Objections to water stains.

Water stains have the great disadvantage of raising the grain more than any of the others. This requires additional sand-papering to bring the surface of the wood back into condition to receive the final finishing materials. This additional sanding, however, is not lost, for it brings out the grain and enhances the beauty of the wood. The opening of the pores makes it possible for the filler to enter deeper and get a better hold on the wood. So the one disadvantage becomes an advantage to the final finish.

Advantages of water stains.

Water stains are transparent, penetrate the wood deeply, and are very inexpensive. Added to these facts the ease with which they are made and used, we have a very desirable article, one that the beginner

may experiment with in a way that the cost of other stains would prohibit in most cases. However, water stains are not held in general favor by professional finishers.

Analine colors.

Water stains are made of both aniline colors and from colors and dyes which are not anilines. The one great objection to aniline stains has been that they fade quickly. This objection is now largely overcome, partly by improvement in the colors themselves, and partly by adding to them a fixing material called a *mordant*—that is, a material which seeks to unite both with the coloring matter and with the wood, or, chemically speaking, has an affinity for both, or, as the dictionary says, makes the color bite the wood. The alkalies and acids are most used as mordants.

A mordant.

Pigment colors.

The objection to the pigment colors is that they are opaque, and, with the one exception, that of Vandyke brown,* they have in the main given way to the aniline stains. Vandyke brown is such a beautiful transparent brown that it answers every purpose for a brown color in every shade.

To apply water stains.

Water stains may be applied with a cloth or swab, because the mordant used with the stain will destroy a brush in time. It is, however, much more easily applied with a brush, and, as a cheap one does just as well as an expensive one, it is well to use the brush. The stain should be applied quickly, the only requirement being that the surface be entirely covered. Before the stain has time to dry the surplus must be wiped off with cloth or waste and the surface rubbed till the color is uniform. If the color is too light, put on two, three, or even more coats until dark enough. If too dark, a damp cloth rubbed over the surface will take up some of the color.

Make a sample finish.

The same stain applied to two different kinds of wood, or even to two samples of the same kind of wood, will not produce the same effect. Consequently the beginner should finish a satisfactory sample of the

* Vandyke brown is a bituminous earth. It is mined mostly in Germany, though some comes from Belgium and Holland. It is washed free from dirt and is ready for use.

wood before attempting to apply the finish to the whole article. The beginner should not be easily discouraged, as it may, and probably will, take several attempts to get the required results, but anything which is worth having is worth working for. When the required results have been obtained with even one process the rest are comparatively easy, for we shall then know what to look for. We should always remember the finish may be the crowning glory of a good piece of construction or the utter ruin of the same piece.

No attempt is made here to give a complete list of stains. It is believed that a few standard colors is all that a school should carry in stock, and if some pupils want other colors let them provide them for themselves. From the stand-point of economy, the teacher should mix his own water stains. Another good reason for so doing is that if the stains are made in the shop there is not that air of mystery which always surrounds a commercial product.

Uses of the Different Kinds of Stains

In general, it may be said that the heavy oil stains may be used on woods which have little or no natural beauty, as in cases where it is desirable to protect the wood, rather than to bring out the beauty.

Volatile oil stains, spirit stains, and water stains are used when color only is wanted. They in no way protect the wood.

A Few Formulæ for Making Stains

BROWN

Vandyke brown—2 pounds.

Caustic potash or caustic soda or concentrated lye—2 ounces.

Water—2 gallons.

Boil until reduced one-half in volume. This makes a concentrated solution, but it may be diluted by adding water to it when

used. It is a very useful stain and one that works well in the hands of a novice. The color may be shaded from a mere hint of brown to almost a black.

BLACK

Nigrocine—any amount.

Bichromate of potash dissolved in water.

Add the bichromate until there is no trace of blue left in the mixture. Then dilute with water to the required shade of black.

To prepare the bichromate for use, pulverize the crystals, place them in water, always having undissolved crystals in the bottom of the dish. Let stand at least twenty-four hours. Shake occasionally so that as much as is possible of the bichromate will dissolve. It is best always to keep such a solution on hand.

Mix the nigrocine in a small amount of the bichromate solution until all lumps are dissolved; then add the remainder. This makes a good stain, with a wide range of shades of black.

BLACK

Extract of logwood—1 pound.

Bichromate of potash crystals—5 ounces.

Water—1 gallon.

Boil to one-half the volume. This will make almost an ebony black. Add water to get the lighter shades.

DARK OR FOREST GREEN

Add a very small amount of aniline green to the desired amount of the above logwood black.

MOSS GREEN

Aniline green dissolved in water. (Soft or distilled water is best.)

MAHOGANY STAINS (FOR ALL KINDS OF WOOD)

Bismarck brown—dissolved in hot soft or distilled water until the desired color is obtained.

The stain given above will cover nearly the whole range of the so-called mission stains. The materials are very common and are inexpensive; they can be obtained from any large paint dealer or ordered through any druggist or merchant who deals in paints and oils.

TO DARKEN MAHOGANY

To give mahogany a rich, dark tone, rub it with a diluted solution of caustic soda, caustic potash, or concentrated lye. It takes several minutes for the color change to take place, as it is caused by a chemical action on the wood. The solution must be very dilute or too dark a color will be obtained. Apply to wood with a swab and wipe off with a cloth.

CAUTION.

Caution.—Great care should be taken in handling the stronger alkalies spoken of above. Do not get the solution on the hands; it will decompose the skin and the nails and make the hands very sore; and it is a rank poison. Bottles or dishes containing the solution should be marked "Poison."

Buy oil stains ready mixed.

If only a small amount of stain is to be used, or if oil stains are wanted, it is probably best to buy the ready-mixed stains, for it is not easy to make oil stains or to get the best materials.

Color of filler.

It will not be necessary to use a colored filler with any of the stains, the formulæ of which are given above, for the filler will take up enough of the stain to color itself.

Covering stains with varnish.

The black and the brown stains given above may be varnished with shellac varnish for the first coat. But the green and the mahogany stain should first be covered with a thin coat of linseed-oil, or some oil varnish, for they are so soluble in alcohol that the color picks up

on the brush to such an extent that a few dippings will so color the varnish as to spoil it.

Staining may also be done by adding coloring matter to the filler, but in general this is not as satisfactory as staining before the filling is done.

FUMING

Very beautiful colors may be obtained on some woods by placing them in a tight room or box in which are placed several open dishes of ammonia. Mahogany, oak, and chestnut take on an especially beautiful color, which may be waxed or filled and varnished as for other stains.

Sand-Papering After Staining

Time to sand-paper.

It is best to allow all stains to dry at least twenty-four hours before sanding down the fibres raised by them, and this is especially true with the water stains. When the stains are first applied the fibres are up out of their natural position, but at the end of a day the water has evaporated, the surface is dry, the fibres have settled back to a normal position, and the extra sanding only tends to bring out the grain. Sanding over a stain should be done with fine paper, about No. $\frac{1}{2}$, for most cabinet surfaces.

Fig. 182—Sand-Papering Stain or Varnish Coat

Holding the sand-paper.

Sand-paper should not be held over the sand-paper block for sanding either the stain coat or the final varnish. While the surface of the wood has been planed, scraped,

and sand-papered before the finish was applied, and is supposed to be in prime condition, there are always slightly raised places which will be rubbed through if the block is used, for it will hold the sand-paper out of the low places and catch the high ones, thus rubbing the finish off in spots.

Protecting the corners and edges. The paper should be cut in small pieces and folded three or four times, so that the edges will be straight and stiff. This will make the paper hold up square into the corners and over the edges, and if held as shown in Fig. 182 the flexibility of the hand will allow the paper to follow evenly the exact contour of the surface. The stained surface should be rubbed perfectly smooth. The color will be somewhat rubbed out, but it can be renewed after the filler has been applied.

Wood Filling

As stated before, if the fibres of the wood are coarse and open, as in oak, or if the pores are open, as in mahogany, then the wood must be filled—that is, some substance must be rubbed into the pores and between the fibres to make the surface level. **Object of filling.** If filling is not done, the varnish will draw back into the pores and openings and will pile up on the closed spots, giving the work a blotchy, pitted surface. The only way to remove such blemishes is to sand-paper the high spots and add varnish until the low places are even, a process which is very expensive both in material and labor. For a long time, however, this was the only way known to finishers, but some one finally thought of first putting some substance into the pores then adding the varnish. **Materials for making fillers.** Various pastes and liquids are now used as fillers, among which are compounds made with corn-starch, whiting, plaster of Paris, and *silex*. Corn-starch is a vegetable compound, but does not set hard enough and is also likely to decompose after a time. Whiting and plaster of Paris set like chalk, are porous, and do not hold to the wood well. **Silex.** Silex is at the present time the king of materials for the body of filler mixtures.

Silex is a name given to a group of rocks, some, but not all, of which may be ground into small, irregular granules. When mixed with the ingredients given below, these needle-like particles penetrate deeply into the pores of the wood and the mixture becomes almost as hard as stone, thus making a hard surface over which to apply any final finish. If silex cannot be obtained it is better to buy a filler mixed ready to be used. To test silex, put a little in a drop of oil and rub it over a piece of glass. It should feel decidedly gritty. If possible, it is best for a teacher to mix his own filler, for there is not only some financial gain, but also the gain of knowing what is being used. Moreover the pupil is given a chance to learn the careful preparation of the materials.

Test of silex.

Formula for Silex Filler

Light turpentine japan—2 parts.
Linseed-oil—1 part.

Measure carefully and put these ingredients together, add silex, a little at a time, being careful to mix thoroughly as each part is added (thorough mixing makes a good filler). Add silex until the mixture is of the consistency of a good, thick paste; then add a small amount of japan varnish or turpentine until the filler is of the consistency of thick paint. A little experimenting will be necessary at first. If the filler dries out granular, more oil should be added; if it takes too long to dry, add more japan varnish. If color is needed, add a little of the color used in the stain, though of course the color must be thoroughly mixed in a small amount of oil before it is added to the bulk of the liquid or there will be lumps of color.

Some experimenting necessary.

Coloring the filler.

Filler is usually applied with a brush, but on small work it may be rubbed over the surface with a cloth or a piece of waste. (*All cloth or waste used for wiping filler or in any other mixture of linseed-oil should be carefully gathered up and burned, for it will take fire*

CAUTION.

in a few hours because of a chemical action called spontaneous combustion.)

Wiping off the filler.

Filler should be allowed to stand on the wood until the wet, glossy appearance takes on a dead, dry look. This usually takes from twenty to thirty minutes, according to the amount of linseed-oil used in the mixture—the more oil the longer the drying necessary. When fairly well dried the surplus filler must be rubbed off the surface. The older workman can do a good piece of work with excelsior, but the beginner should use only cloth or waste. In wiping off the filler, the wiping should be done as much as possible across the grain. Rub lightly at first, then as the filler gets harder and the cloth more saturated with filler considerable pressure may be used, thus forcing the filler into the pores. The final rubbing should be done carefully and with a clean cloth. Great care must be taken to leave the pores and the spaces between the fibres even with the surface with little if any filler left on the surface. A small, flat stick should be used to take the filler out of the corners. No filler should be left overnight without first having been rubbed down. After being properly rubbed the filler should stand from twenty-four to forty-eight hours, or until the oil has hardened. If the final finishing materials are placed over the filler before it is thoroughly dry, the filler will dry out in time, will shrink in drying, and thus cause the varnish to crack. The little fine cracks so often seen over the surface of finished wood is caused by the drying of the filler after the varnish was applied.

To remove filler from corners.

Time for filler to dry.

Sand-papering the filler.

The final operation of filling is to rub the surface well with fine sandpaper in order to remove all surplus filler. If this is not done the finish will be cloudy, and if any considerable amount of filler is left on the surface it will cleave off, leaving an unsightly hole in the finish. It will be seen from the above that filling is a vital part of good wood finishing.

Staining over the filler.

While the last rubbing and sanding of the filler coat is being done the stain is likely to be rubbed, streaked, and present a thin, washed-

out appearance. The foundation of the stain is left, however, and the even, pure tone may be brought back by brushing stain over the surface and quickly wiping off with a cloth.

With the final stain coat thoroughly dried, which will take at least twenty-four hours, we are ready for the last step in the finish, that of varnishing.

Varnishing

The author is well aware of the fact that varnishing cannot be learned from a book. It seems simple, indeed, to take a brush and cover the surface of a piece of wood with a liquid, but varnishing is more than a mere smearing of the surface. It is the final step in the process of making a useful, permanently beautiful article, and requires much care and patience. Varnish is defined as a resinous material dissolved in a liquid, which, when exposed to the air, will evaporate or become hard by chemical action, leaving the resinous material spread in an even coat on the surface over which it has been painted. This definition sounds simple, but in reality the composition of most varnishes is very complicated, and a great variety of materials and processes are used, the detailed discussion of which is not within the scope of a book like this. To those who wish to go further into the subject a good encyclopædia and a list of reference books in subject-matter will give valuable aid.

Definition of varnish.

While, as stated above, the composition of varnish is complicated, there are, however, a few fundamental facts which even an occasional user of varnish must know if he does any successful varnishing.

Varnishes may be divided into two general classes: 1. Oil varnishes. 2. Spirit varnishes.

Oil and spirit varnishes.

Oil varnishes are further divided into two distinct groups: 1. Fat-oil varnishes. 2. Volatile-oil varnishes.

The fat-oil varnishes are made by dissolving a resin in an oil which hardens by chemical action when exposed to the air. The body of

the oil remains in the varnish; it adds materially to the lustre and helps to set or fix the varnish.

Varnish materials. Linseed-oil is the *fat oil* most used in the manufacture of varnish. The best resins are amber, animé, copals, sandarac, resin, and kauri. The properties of these materials may be learned by referring to an encyclopædia.

Thinners. Varnishes made with fat oils and resins are too thick to spread well and must be thinned with some thin liquid. They dry slowly and materials are added to make them dry more rapidly. The process of manufacturing the fat-oil varnishes is so complicated that the finisher always buys them mixed ready for use.

Volatile oils. *The volatile-oil varnishes* are made with a resin or gum dissolved in an oil which evaporates when exposed to the air and in so doing does not change the chemical composition. These oils do not add to the varnish but merely act as solvents for the resin and gum. Turpentine is classed with the volatile oils; it also has some of the properties of the fat oils in that it evaporates and leaves a resinous residue which helps to fix the varnish. The oils which belong exclusively to the volatile oils and are much used in the manufacture of varnish are the coal oils—naphtha and benzine. There are others, but these will suffice to call attention to the type.

Spirit varnishes are made by dissolving gum, resin, or lacs in some kind of spirits. The spirits act merely as a solvent; they evaporate very quickly leaving the dissolved substance as a varnish coat. No thinners or driers are needed other than the body and the solvent. The spirit varnishes are easy to mix, and the finisher often mixes his own varnish. There is but one kind of spirit varnish that is in common use and that is shellac varnish.

Shellac varnish. Shellac varnish is made by dissolving lac in alcohol. Lac is a resinous material which exudes from the sides of a very small scale insect that lives mostly on the banyan-tree. Shellac is put on the market, after being cleaned, in thin flakes and slabs. The varnish has a good base and is much used.

A general statement of the various kinds of varnish may be made as follows:

General facts about varnish.

The oil varnishes are bought mixed ready for use. The fat varnishes are likely to become thick and need thinning before they can be used. They are heavy and hard to apply, though they are usually the best and most expensive kind.

Volatile-oil varnishes are also bought ready to use. If left in an open dish the solvent evaporates very quickly.

The spirit varnish, shellac, may be mixed by the finisher to good advantage. It also evaporates rapidly from an open vessel.

Substitutes for best varnish materials.

There are many substitutes for the better varnish materials, and the only way for an inexperienced person to get good material is to get it from a trustworthy dealer and be willing to pay a fair price for an article that is marked pure and bears the name of a reliable manufacturer.

Commercial packages are usually marked with full directions how to use the varnish which they contain.

What has been said with regard to oils, spirits, resins, etc., is intended merely to put the amateur finisher on his guard so that he may appreciate the fact that varnishing is a serious business. With this understanding, we can now assume that the workman is supplied with a varnish which is in good condition to be applied to a piece of woodwork.

Brushes

Kind and size of brushes.

The next thing the finisher must do is to select a suitable brush, and as the selection of a brush depends entirely upon the use to be made of it, only a few general rules can be given. Brushes are made of both bristles and camel's hair. Either kind may be used as a varnish brush, though the camel's hair is best for fancy work. Round, oval, or flat brushes in all sizes may be obtained. The size of the brush should be in proportion to the size of the work, but it should be large enough to

enable the workman to cover the surface quickly so that an even coat may be applied before the varnish begins to dry. Do not try to be too economical in purchasing brushes. A good brush will do better work and last longer than a cheap one. When through with the brush wash it in the thinner used in the varnish you have been using and wrap it in an oiled paper. Do not try to use a brush that sheds bristles or hair on your work. Clean shellac brushes in borax water; or common baking soda will do if borax is not at hand.

Care of brushes.

Applying the Varnish

With the surface of the wood well filled and the filler well dried, we are ready to apply the varnish. If the varnish coat is to have a perfect surface the wood must be thoroughly sealed, so that it will not be possible for the varnish to draw back into the pores. The filler will not do this if a slow-drying varnish is used. For that reason one or two coats of shellac are applied to the wood first. This varnish (described on page 132) sets in a few minutes and is thoroughly hard in six or seven hours. It has a good, hard gum and will seal the wood against either water or varnish. All dust must be wiped from a piece of wood that is to be varnished.

Applying shellac varnish.

Shellac must be kept in an earthen or glass dish, and is applied with an oval brush varying in size according to the extent of the surface to be varnished. A wire should be drawn across the top of the shellac dish so that the surplus shellac wiped off the brush will fall back into the can. (See shellac dish, finishing outfit, page 141.) Care should be taken not to have the shellac too thick or it will not spread well. The brush should not contain too much shellac, and the attempt should not be made to cover too much surface with one filling of the brush. Shellac dries so quickly that the first brushing is all that is possible to do, for subsequent brushing will only deface the first coat.

Do All Varnishing Parallel to the Grain

The laps should be made along a straight line parallel to the grain, as in Fig. 183, rather than across the grain, as in Fig. 183*a*. The dark parts show where the shellac has been applied. Shellac that feels dry to the hand is not always dry. Three or four hours at least should elapse between coats, and, if rubbing or sanding is to be done, the shellac should dry at least six or seven hours, and even a longer time is better. A slight fuzz or roughness usually comes up on the wood when the first coat of shellac is applied. That should be sanded very lightly with No. 00 or No. 0 sand-paper, care being taken not to rub through the shellac.

Time for shellac to dry.

Sand-papering shellac coat.

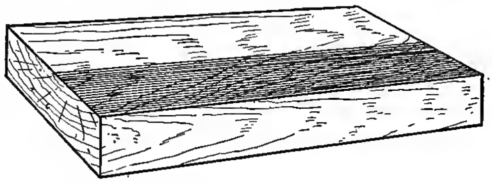
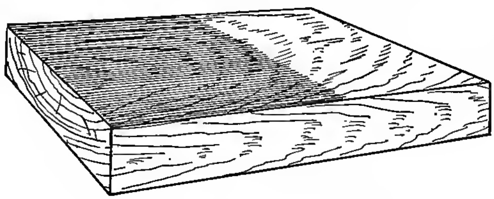


Fig. 183—Correct Way to Apply Varnish

Applying Fat Oil and Other Slow-Drying Varnishes



183a—Incorrect Way to Apply Varnish

As stated above, all dust must be removed from the surfaces before the varnish is applied. This should be done with a damp cloth so that the dust will not be left flying in the air. The room in which the varnishing is done must also be entirely closed and free from dirt, for any dust which settles on soft varnish sticks to it, and as it usually takes several hours for the heavy oil varnishes to dry, a small amount of dust in the air will cause serious trouble in that amount of time. The temperature should not drop below 65° F., for if the varnish is chilled before it is dry it will not harden.

Work must be free from dust.

Varnish should be applied much the same as shellac spoken of above. The stroke of the brush should always be parallel to the

grain of the wood. In the case of the slow-drying varnishes, surplus varnish can be removed by added brushing, provided that brushing be done at once. If too much varnish is put on in one coat it will blister and dry thicker in some spots than in others. One should also be careful not to spread the varnish too thin.

Blisters in varnish.

Watch all edges. When the brush is dragged over an edge it is likely to shed considerable varnish, which will drizzle down and dry in unsightly streaks that will be hard to remove. If the varnish is not to be rubbed, two or three coats will make a good surface.

Sanding and Rubbing

After all the filling and shellacking it is seldom possible to have a perfect surface when the final varnish coats are finished. When sufficient varnish has been applied so that there is little danger of rubbing through, it will be necessary to sand-paper until all the pits in the varnish are removed. The sanding is done with the paper folded and held in the hand, as in rubbing the stain coat. (Page 127, Fig. 182.) Great care must be taken not to rub too hard over the edge or at the ends of the stroke, for if the varnish is rubbed through it will cause an unsightly spot which will be difficult to remove.

Sand-papering varnish.

Steel wool.

Steel Wool may be used as a substitute for sand-paper. It is composed of fine steel threads merely rolled together in a bundle and held in the hand as is the sand-paper. Steel wool is sold in one-pound packages. It cuts much faster than the sand-paper and does not have the same tendency to scratch. It is, indeed, very efficient in its work, but, since it cuts faster, more care must be taken not to rub through the varnish. The one objection to it is that an occasional steel sliver gets into the hand.

Rubbing with pumice-stone.

When the surface is level and all the scratches and defects are out the final finish is put on by rubbing with pumice-stone and oil. The

oil most in use for rubbing is especially prepared for that purpose, though linseed-oil may be used. If a dull finish is desired, the rubbing is done with pumice-stone and water. For most work the oil is put in one dish and the pumice-stone in another; the rubbing pad, which consists of a special felt pad or a tight roll of burlap, is first dipped into the oil, then into the pumice-stone, and is rubbed over the surface the same as sand-paper. The condition of the surface may be seen any time by wiping a small spot and looking at it at an angle toward the light. When the required finish is obtained the oil should be carefully removed at once or it will soften the varnish. The chief requisite of good rubbing is extreme care. The following is a general statement of the things to do and those not to do:

Rubbing oil.

Rubbing pad.

To see condition of finish.

1. Be sure that the varnish is thoroughly dry before doing any sanding or rubbing. It is a waste of time and material to hurry a finish by not giving it time to harden. The varnish should be hard enough to resist the action of the thumb nail before it is hard enough to rub.

General statement.

2. Always rub with the grain.

3. Be careful not to rub through the varnish on the edges and corners.

4. To see condition of finish, remove the oil from a spot and look at it at an angle toward the light.

5. When finish is done, clean the oil or water from the surface quickly so that it will not injure the varnish.

6. Burn all waste or rags with oil on them, as they will take fire by chemical action.

This will complete a standard finish, one which will add both beauty and protection to the finished article. Ability to apply such a finish will mean ability to apply any finish.

Many do not think the polished surface beautiful and have sacrificed protection for mere beauty, which only lasts for a short time; though there are some dull finishes that do very well on some kinds of work.

Unless special provisions are made it is almost impossible to use slow-drying varnish for school work, chiefly because the dust settles into it too much.

Shellac Finish

The wood is put into condition by planing, scraping, sanding, and if necessary it is stained and filled exactly as for the standard varnish given above. Three or four coats of shellac are applied (one each day), and the sanding and rubbing are done the same as the standard varnish, though as a rule the rubbing is only sufficient to produce a smooth surface without a polish.

Egg-Shell Finish

The dull egg-shell finish is made by simply allowing the last coat of the shellac varnish as applied above to remain without sanding or rubbing.

While the shellac is not as good as some of the other varnishes for the final finish, it has the advantage of drying so quickly that dust will not stick to it in ten or fifteen minutes after it is applied. This is, indeed, a great feature where the work is to be done in the open shop. The shellac finishes are much more durable, sanitary, and protect the wood much better than the wax finishes given below. If any of the commercial finishes are used, the directions on the packages should be followed.

Wax Finish

The only really good thing about wax finish is that it is easily applied. On some kinds of wood, notably oak, it gives a beautiful dull tone. The beauty, however, is very fleeting, for it will not withstand water or wear. It does not protect the wood for it does not harden well, and much of the dust which settles on it is rubbed into the wax, causing

the surface to become grimy in a very short time. When all is said, there is little about a wax finish to recommend it. It does not prevent the stain from coming off in any fabric which may be placed upon it. As a floor finish, it is used a great deal because the worn spots are easily refinished. The wax is composed of beeswax dissolved in turpentine. The turpentine acts merely as a solvent or a thinner, and only a sufficient amount is added to make the wax thin enough to spread. Twenty per cent. of resin is sometimes used to make the wax harder.

Composition of wax.

Hot turpentine is a better solvent for the wax than cold, but one must be extremely careful that the turpentine does not take fire, as it is very inflammable and when hot gives off a gas which is also apt to take fire. The heating should always be done in a double boiler, like a glue-pot or a rice cooker.

The wax is applied by brushing over the surface with a stiff brush, or it may be rubbed on with a cloth; in any case the rubbing should be continued until the wax is well rubbed in and all the surplus is off the surface. It will not be necessary to fill waxed surfaces, for the wax will work into the wood. Wax may be used on some of the first problems, but do not deceive yourself into thinking that you have a real finish.

To apply wax finish.

Painting

As stated at the beginning of the chapter on finishing, painting covers the wood and does not attempt to show any of its natural beauty. The chief object is to protect the wood, and the only beauty is in the color of the paint used. The best paints are made with a compound of lead or zinc as a base, linseed-oil as a solvent, turpentine as a thinner, and various compounds as driers. The different colors are made by adding different-colored pigments which have been ground in oil, or if the dry color is used it is best to work it thoroughly with oil. This will avoid color lumps in the paint. Some of the very best coach paints have a little varnish mixed with them, for it gives the

Composition of paint.

paint a hard, glossy surface which is very durable. The surface of the wood does not need to be in as good condition for painting as it does for varnishing. Filling is not necessary, though all nail heads should be covered and all nail holes should be filled with putty. The putty is pressed into the holes with a flat putty-knife made especially for that purpose. It is done after the first or what is called the prime coat of paint has been applied, for it will not stick if put on the bare wood. It is well to remember this when puttying in window glass.

Applying paint.

Paint is applied with a brush the size of which varies according to the size of the surface to be covered. The brushing should be done parallel to the grain, and care should be taken to make the laps even and the coat of paint of uniform thickness. Do not try to carry too much paint in the brush at one time, for it will run out, waste the paint, and make a slovenly piece of work. Water should not come in contact with paint before the paint has time to dry. Each coat of paint should have ample time to dry before the next is added. If the coats are piled one on the other too rapidly, or the paint is too thick when applied, blisters or bubbles will appear on the surface as the paint dries.

Time for paint to dry.

Care of brushes.

Brushes should always be washed in turpentine and all paint carefully removed before they are put away.

Fig. 184—Box for Finishing Materials

There are so many cheap, worthless paints on the market that one should always be careful to buy of a reliable paint dealer and be willing to pay a reasonable price for an article marked pure lead or zinc paint and stamped with the name of a reliable manufacturer.

For outside work that must withstand water there is nothing better than a good white-lead paint.

Care of Finishing Materials and the Finishing Outfit

One of the greatest difficulties about finishing in the school or home shop is the care and handling of the finishing materials. It is seldom possible to have a special room for such work, and in many cases there is not sufficient space for a special table. Even if such places are provided they are likely to become mere gathering places which lead to general confusion. Brushes will be changed from one color to the other, materials will be wasted, and the teacher will not have as good an opportunity to watch the work as he will if each pupil worked alone at his own desk. In an effort to solve these perplexing problems in a large high-school, an outfit has been provided for each teacher having finishing work in charge. This outfit consists of a box 14″ wide, 20″ long, and 14″ high, outside dimensions. (See Fig. 184.) It is made of $\frac{5}{8}''$ poplar. The top is 2″ deep on the inside and is provided with loops for holding brushes, etc. Fig. 184*a* is a frame placed in the bottom of the box for holding the finishing dishes, which consist of one can of shellac, one can of brown stain, one can of black stain, one can of wood filler, one bottle of bichromate of potash crystals in water ready for mixing black stain.

Finishing outfit.

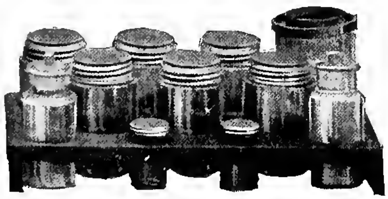


Fig. 184a—Tray for Finishing Box

A few other special colors are kept in a general stock and are made up when needed. The black and the brown give such a wide range of tones that the special colors are seldom used. The student is not allowed to handle the general stock of materials. He is given what he needs for the particular finish and is held

responsible for its careful use. The finishing is all done at the individual bench, which makes it easy for the teacher to place the responsibility for careless work. This plan has proved very success-

Fig. 184b—Varnish Dish*

ful. The object is to give a general idea of wood finishing with ability to handle a few standard materials.

* Varnish Dish designed by Mr. Paul W. Covert, head of the Manual Training Department of the Indianapolis Manual Training High School.

CHAPTER VII

SOME ESSENTIALS OF CONSTRUCTIVE DESIGN

In the preceding chapters a number of facts about the manipulation of tools and materials have been given. The problems considered were ready-made and fully stated, and the work was purely mechanical. It is time now to give some attention to the statement of new and original problems.

Object of construction. The "Encyclopædia Britannica" says: "The object of construction is to adapt, and combine fit materials in such a manner that they shall retain in use the disposition assigned to them." From this statement of the object of construction, the object of *Constructive Design* may be stated as the selecting of the fit materials and designating the combination which will meet the requirements of construction. **Object of constructive design.**

As one example of constructive design which will embody the ideas of construction and fitness stated above, let us consider the development of a chair.

The requirements of a chair are:

1. Strength to hold us up when we sit on it.
2. To furnish a comfortable place to sit.
3. It must be in keeping with the surroundings.

If we are living in a rough, temporary logging camp and wish a place for the men to sit at the dining table, a bench, as in Fig. 185, will answer all requirements. It is strong, is reasonably comfortable for a short sitting, and is in keeping with the makeshift surroundings. If, however, a settler living in the neighborhood of such a camp would make a bench or chair for a general living or eating room, some care

in construction, as in Fig. 186, would be more in keeping with the permanent home. But even this would not be as comfortable or inviting for an evening lounge before a glowing fireplace as would a

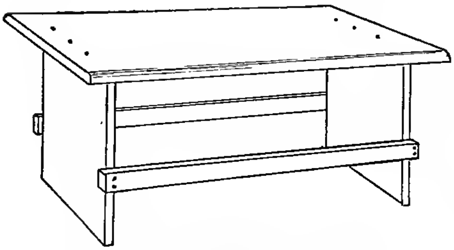


Fig. 185—Chair Suitable for Temporary Camp

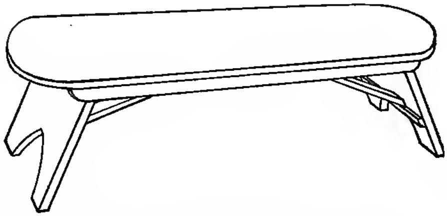


Fig. 186—Chair or Bench Suitable for Permanent Pioneer Home

chair with a back, as shown in Fig. 187. If a sheepskin, tanned with the wool on, were thrown over the seat and back of such a chair it would compete in comfort and strength with the fancy leather-cushioned Morris-chair shown in Fig. 188, or with any other chair for

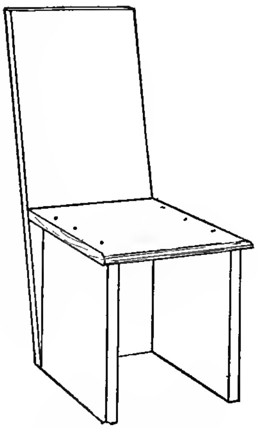


Fig. 187—Easy Chair for Pioneer Home

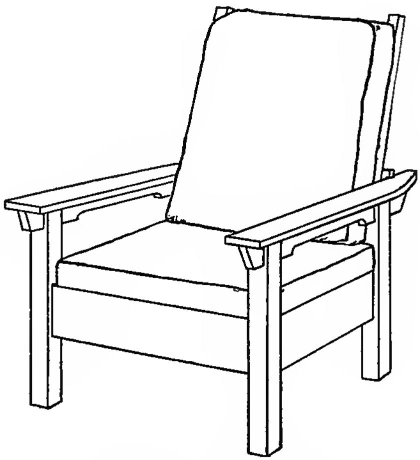


Fig. 188—Modern Morris-Chair

that matter. Yet one would not want to place a rough chair covered with sheepskin in a well-arranged country or city home where even a few of the modern furnishings are used. It is easy to see why there is something about the Morris-chair that will always give it a place in refined surroundings, a place which cannot be given to any of the other chairs shown. One would not be likely to choose a straight-backed chair, like the one shown in Fig. 189, in which to sit for an evening to read a favorite book. But the same chair at a writing-desk or at a dining-table, where the back is not used for the support of the body, would answer the purpose much better than would the Morris-chair.

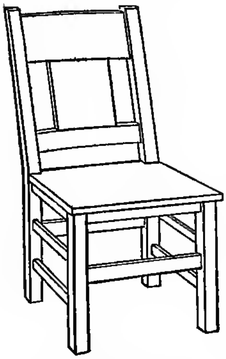


Fig. 189—Straight-Back Dining-Room Chair

Considered by itself, the chair shown in Fig. 190 is not at all pleasing. The back is too short, or, in other words, it is out of proportion with the other parts of the chair. Or, as the artist would say, the chair is out of harmony with itself. If the same chair is placed in a crowded restaurant where space is a very important consideration, and it can be seen pushed under the table, as in Fig. 191, the short back does not seem so much out of place. The lack of proportion in the individual piece is largely overcome by the requirements of service. No position and no service consideration could, however, overcome such a lack of symmetry as is shown in the chair, Fig. 192. The round and the square legs on the same chair and the showy turned brace in combination with the square ones are serious defects. For strength and comfort the chair might do as well as the one shown in Fig. 189, but the elaborate construction and the lack of harmony in the parts would make the chair seem old and out of place in a logging camp or a permanent home.

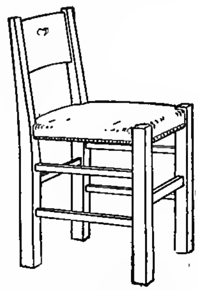


Fig. 190—Low-Back Chair for Special Use

It is thus seen that a lack of fitness as well as a lack of beauty or good workmanship excludes an article from service. What is meant by fitness would be clearly shown if we should put the bench made for a logging camp (Fig. 185) into an elaborate home, or the Morris-chair, with its leather cushions, in a blacksmith-shop. If we try to make a chair merely an object of beauty to be looked at and not used, then again we have missed the object of chair construction and cannot find a suitable place for the product.

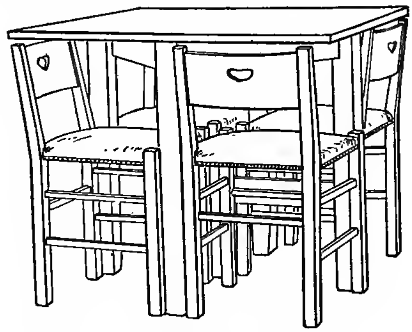


Fig. 191—Chairs Placed Under Table to Save Space

What has been said about the construction of a chair may be said about any other construction. Between the extreme ideas of service, as is shown in the bench (Fig. 185), and the attempt at over-ornamentation, as in Fig. 192, there is a great field of design which seeks within the limits of service to make the product as beautiful and pleasing as the surroundings will warrant.

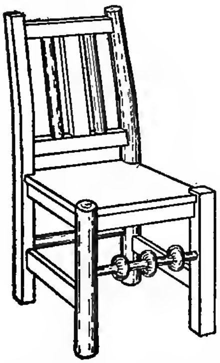


Fig. 192—Chair Out of Harmony with Itself and All Surroundings

What the Designer Must Know if He is to Get the Best and Most Economical Production

The designer must know the use to be made of the article he is to design and if possible the place in which it is to be used. He must know the available materials. There is no general list of construction materials which can be obtained everywhere. The good designer or the careful workman, though he is to make but a few pieces, will acquaint himself with the materials carried in stock by the dealers in his

locality. Special materials or even standard materials which must be ordered special, cost much more than materials ready in stock. The designer should know how to combine and join materials both for strength and for beauty. He should know the tools to be used and the ability of the workman who is to use them. Otherwise he will be likely to demand too much or too little. The beginner will learn much about tools and combinations by referring to the chapters under those headings.

Facts Which the Designer Should Know

The standard height of the seat of a chair of the dining-room type is 18″. Rockers and chairs with deep seats are made lower.

The standard height of a writing-desk, office desk, or library table is 30″.

The standard height of a work-bench intended for the use of an adult is 34″.

The standard height of a piano bench is 20″.

Tabourets are usually made 18″ high, though the height varies according to the use to be made of them.

Sheet music is about 12″ x 14″. A music cabinet should be at least one inch wider and deeper on the inside.

Bookcases are from 10″ to 12″ deep inside.

An umbrella-holder is from 24″ to 26″ high, from the bottom of the pan to the top of the cross-rails.

The weak point in a chair is where the seat rails are fastened to the back legs.

The distance between the shelves of a magazine stand should be greatest at the bottom, and should decrease by three-quarters of an inch between each pair of shelves from the bottom toward the top.

Hall trees are usually made from 70″ to 72″ high over all, the hooks being from four to eight inches lower.

CHAPTER VIII

SUGGESTIONS FOR A COURSE OF STUDY IN WOOD-WORK

Part I. For Seventh and Eighth Grades

THE object of the first work is to become familiar with the common tools—to learn how to adjust them, how to use them to the best advantage, and to gain some skill in their use so that the student can gradually do better and more efficient work. As stated in the first chapter, the most simple problem the student can have is shaping a piece of wood to three dimensions. To do this he must know the following:

1. How to measure with a ruler or scale.
2. How to saw to a line.
3. How to plane.
4. How to use the try square as a straight-edge and as a square.
5. How to use the gauge.
6. How to use the knife and try square for making lines.

The operations in the proper order will be as follows:

1. Make *working face* and *mark* it.
2. Make *joint edge* and *mark* it.
3. Use gauge to make lines parallel to a marked face.
4. Measure length.
5. Draw lines across the grain with knife and square.
6. Saw close to line.
7. End planing.

8. Planing third side.
9. Planing fourth side.

A hasty glance at this outline or through the first chapter will show that, although the problem is a simple one, it involves a number of tools and operations all of which are new. To make it easier we will first do just a part of this problem.

Problem No. 1

Poplar or Pine: 1 piece $\frac{3}{4}''$ x $3''$ x $24''$, made to thickness and width only.

Read the first three pages of the first chapter. Note carefully what is said on page 3 about writing an order for a piece of lumber.

Mill order for stock. The piece for the first problem is cut for us $\frac{7}{8}''$ x $3\frac{1}{4}''$ x $24\frac{1}{2}''$, so we can omit for a time what is said about the saw on pages 4, 5, 6, and 7.

Selecting stock. The first thing to do is to measure the stock to make sure that we have enough material, and to examine it carefully to see if there are any defects, such as cracks, knots, etc., which will make it unfit for use.

Working face. The first work to be done on the piece is to plane a flat, true surface, which is called a working face. (Read "Planing the First or Working Face," pages 11 to 16 inclusive.)

Select the best surface, hold it up to the eye, and sight across it to see if it is straight and flat. If it is not flat, plane the places which are high and which cause the unevenness. The teacher will select the plane to do this piece, but in time the pupil must learn to select his own plane.

Parts of plane. To learn how to put the parts of the plane together, the names of the parts, their use, and how to adjust them, read "Adjusting Plane," pages 13, 14, and 15.

To plane the piece to dimensions, follow the general directions given on page 16 to End Planing, page 20.

In general, the piece to be planed should be held against the bench stop on top of the bench, and the whole stock or base of the plane should rest on the piece that is being planed.

What we should know.

From the text and in making the first piece we should learn:

1. To write the order for the material.
2. To measure the material to see if we have enough.
3. To examine the material to make sure that it has no serious defects.
4. To make the working face and joint edge and test them with the square.
5. To set the gauge and to draw lines with it.
6. To make the third and fourth faces.

We should become very familiar with these *tools* and *operations* and with the *methods* of doing the work, for we shall use them in every piece of wood-work that we do.

Problem No. 2

Using the gauge.

To get practice with the gauge, take the piece just made and draw lines $\frac{1}{4}''$ apart on the working face parallel to the joint edge. Note carefully what has been said about the gauge and its use on pages 17, 18, and 19. Check each line as directed on page 19, Fig. 37.

Be sure that the lines are uniform and accurate to the extreme ends of the piece.

When the working face is lined, turn the piece over and make the same lines on the face opposite. Test each line as before and see if the first lining cannot be improved upon.

Problem No. 3

Use the same piece as for Problems Nos. 1 and 2. Make eight lines entirely around the piece 1″ apart, eight $\frac{3}{4}$″ apart, and eight $\frac{1}{2}$″ apart. These lines are to be made with the knife and square across the width of the piece.

Making lines across the grain.

Read carefully what is said about the rule, the knife, and the square on pages 21, 22 and 23.

Remember: When testing for squareness with the square always keep the head or beam against a marked face. In making the lines as directed above, great care should be taken to make the lines check accurately around the piece.

Problem No. 4

Use the same piece as in making Problems Nos. 1, 2, and 3. The piece will now be marked off or laid out as in Fig. 193. The problem is to saw off the blocks marked out in the last piece.

Place the piece to be sawed upon the bench-hook and with the back saw saw off the blocks. Read carefully what it said about the back saw and its use on pages 39, 40, 41 and 42.

The blocks should be sawed, leaving one-half of the line on the large piece. This is called splitting the line with the saw. Fig. 194 shows a saw cut made part way across the piece, showing the relation of the saw cut and the line.

Splitting line with saw.

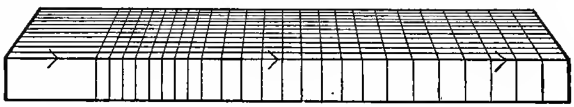


Fig. 193—Problem No. 4 Marked Out Ready for Sawing

After each cut test the end of the piece with the square, both from the working face and the joint edge. If the cut has not been made straight, note the error carefully and make a great effort to avoid it on the next cut.

Test after each cut.

Keep all the blocks numbered and note the improvement as the work progresses.

In the first cutting with the saw you will often find that you saw off the line in the same direction every time. It is best, therefore, to start each cut on the corner between the marked face and the joint edge, so that the test will show where the error is being made. A known fault is more than half corrected. Do not be content until you can measure, plane, make lines with the gauge and knife, and saw to the line with the back saw.

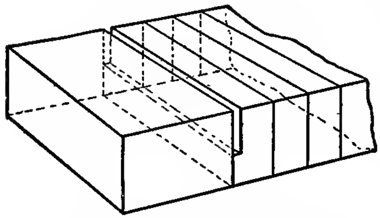


Fig. 194—Showing Saw Cut Splitting the Line

Problem No. 5

Problem No. 5 is to make a bench-hook similar to the one used in Problem No. 4 or to the one shown in the picture. (Fig. 195.)

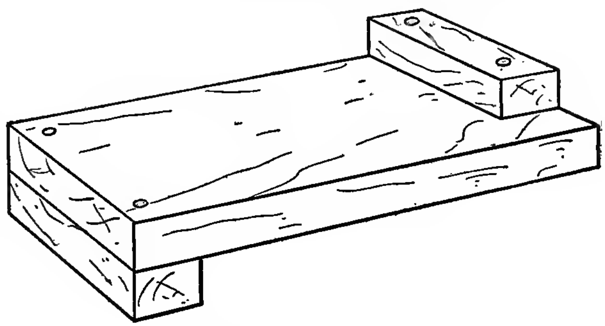


Fig. 195—Bench-Hook

The statement of three dimensions of each part of the hook will not be sufficient, for such a statement will not tell how the parts are fastened together. We cannot measure a drawing as shown in Fig. 195 because we are looking at the piece at an angle and the lines appear shortened. The mechanic, however, makes use of a word and picture language which may be used to state any mechanical problem. We will use that language to state the problem of the

Language of the mechanic.

bench-hook, but to make it easier we will separate the parts, as in Fig. 195*a*, and consider each piece by itself.

Problem stated by the use of mechanical drawing.

Let us take any part, say the base piece (*A*, Fig. 195*a*), and look straight down on the top of it. We shall see what is shown in *A*, Fig. 195*b*. All the lines we can see will be shown in their true length, because we are looking straight at them. We could measure such a drawing crosswise and get the width, and lengthwise and get the length. The holes for the fastening pins are also shown in their true positions. The width and length of the piece and the position of the pinholes are not all we want, for we must also know the thickness.

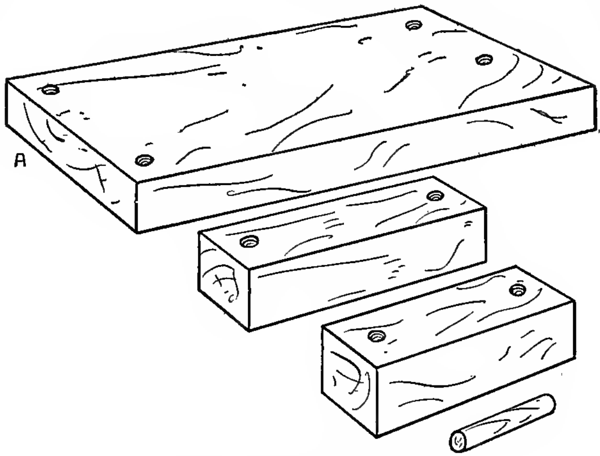


Fig. 195a—Parts of the Bench-Hook

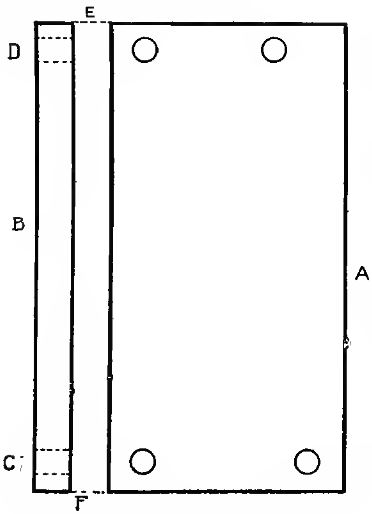


Fig. 195b—Top and Edge View of Base of Bench-Hook

We cannot, however, get the thickness from the top view—we must look at an end or an edge. If we turn the piece so as to see the left edge we shall see what is shown in *B*, Fig. 195*b*. The dotted lines *C* and *D* show where the pinholes would be if we could see them.

Inasmuch as *B* is the drawing of

the left edge of the base, we will place it at the left side and join it to the base with the dotted lines E and F, so that we shall always know the relation between the two drawings.

Measuring the drawing.

We could now measure the view B crosswise to get the thickness, and lengthwise to get the length. The width and the position of the pinholes are obtained from A. That is, by measuring both views we could get all the information desired. But if every one who used a drawing were compelled to measure it, it would take too much time and lead to a great many mistakes. For these reasons the one who is making a drawing writes the dimensions on it, as is shown in Fig. 195*c*.

Dimensions on drawing.

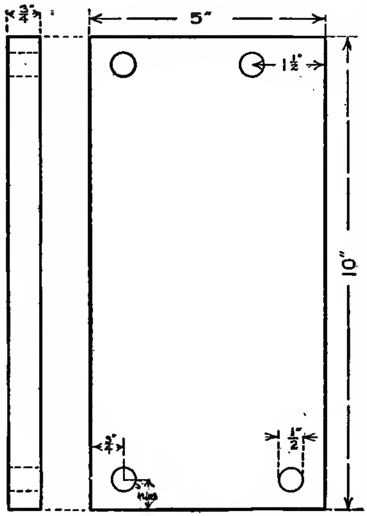


Fig. 195c—Complete Mechanical Drawing of the Base-Board for Bench-Hook.

Reading the drawing.

Fig. 195*c* is a complete mechanical drawing of the base-board of the bench-hook. To write an order for the stock or material in the base we must find the thickness, width, and length on the drawing. As said before, the thickness will be found on an end or an edge view. Look at the upper end of the edge drawing. (Fig. 195*c*.) We find $\frac{3}{4}''$ marked in a line which has an arrow-head on each end. This means that it is $\frac{3}{4}''$ between the points of the arrow heads. The dotted lines leading up to the arrow-heads mean that the distance between the arrow-heads is the distance between the points from which the dotted lines start.

Read carefully: "Dimensions on Mechanical Drawings," pages 33 and 34.

At the end of the drawing we find $5''$ written within a dash line which also ends in arrow-heads, the dotted lines at the points of

which come to the edges of the board. This means that 5″ is the width of the board.

In the same way the 10″ written in the line at the side is the length. Find the arrow-heads and the dotted lines which lead up to them the same as for thickness and width.

The order for the stock or material in the base-board will be written as follows: 1 piece $\frac{3}{4}''$ x 5″ x 10″. The position of the pinholes is shown by the figures, arrow-heads, etc., and may be easily read from the drawing.

Fig. 195*d* gives a complete mechanical drawing of the cross-pieces and the fastening pins, the remaining parts of the bench-hooks. These drawings are the same as for the base piece, except that the right end is shown instead of the left, and because of that, the end view is to the right of the top view.

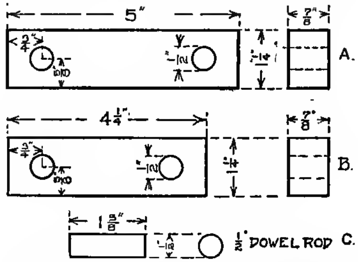


Fig. 195d—Complete Mechanical Drawings of Cross-Pieces and Pin for Bench-Hook

Detail order.

From the drawings we can read the dimensions and write the order for the entire stock as follows:

1 piece $\frac{7}{8}''$ x $1\frac{1}{4}''$ x 5″—From *A*, Fig. 195*d*
1 piece $\frac{7}{8}''$ x $1\frac{1}{4}''$ x $4\frac{1}{4}''$—From *B*, Fig. 195*d*
4 pieces $\frac{1}{2}''$ dowel rod $1\frac{5}{8}''$ long—From *C*, Figs. 195*d* and 195*c*.
1 piece $\frac{3}{4}''$ x 5″ x 10″—From Fig. 195*c*

Such an order gives us a very definite problem. The dimensions given in the order are, however, the finished dimensions. We must allow some extra material to be cut away in making a finish. From the above order for the cross-pieces we learn that they are the same thickness and width, and together make a piece only $9\frac{1}{4}''$ long. It will be easier for us to work these two pieces to dimensions in one piece, and cut them to length, for it will save handling the tools for at least one whole operation.

Combination of similar pieces.

Mill order.

After grouping the first two pieces and allowing material for finish, the mill order for stock will be:

1 piece 1″ x $1\frac{1}{2}$″ x 10″
1 piece $\frac{1}{2}$″ dowel rod 8″
1 piece $\frac{7}{8}$″ x $5\frac{1}{4}$″ x $10\frac{1}{2}$″

To make the first piece of the bench-hook will be merely a review of the first problem. (Read carefully the steps in making the first problem on pages 149 and 150.) When the four faces are planed, lay out the pieces as shown in Fig. 195*e*.

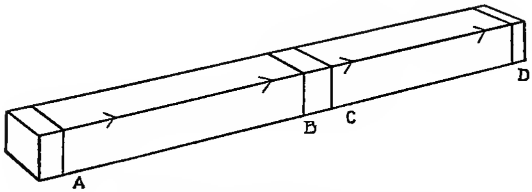


Fig. 195e—Cross-Pieces of Bench-Hook, Planned and Laid Out Ready for Sawing to Lengths

Lines for end cuts.

The lines *A B C D* are made entirely around the piece with the knife and square, the same as in the fourth problem. Saw to these lines, leaving one-half the line on the piece you wish to keep. The two lines (*B* and *C*) in the centre are made because it is usually not possible, when sawing free hand, to saw both sides of the cut smooth and square until we have had considerable practice in using the saw. If sawed carefully the ends will not need any further finish.

The stock for the base piece will be rough sawed and machine planed to $\frac{7}{8}$″ x $5\frac{1}{4}$″ x $10\frac{1}{2}$″. This allows $\frac{1}{8}$″ in thickness, $\frac{1}{4}$″ in width, and $\frac{1}{2}$″ in length for finishing.

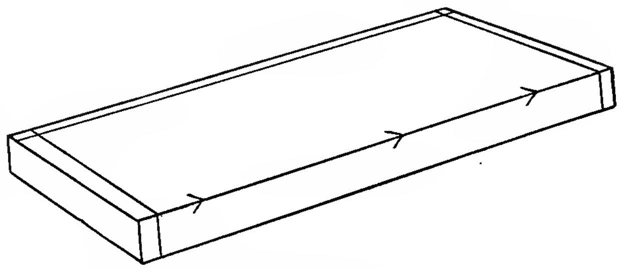


Fig 195f—Base Piece of Bench-Hook Laid Out Ready for End Planing

Plane the working face and joint edge and mark them as in any other piece. Then lay out with gauge, knife, and square, marking the width

and length, as is shown in Fig. 195*f*. The end planing should be done before the third side is finished. (Read carefully what is said about End Planing on pages 21, 22, 23, and 24.) Before planing to the end lines it will be best to saw off all but a very small amount of the surplus stock. Until we are able to use the saw accurately, it will be best for us to make a second line very close to the first and saw to the centre of the second line the same as in making the other saw cuts. The saw cut should be made so close to the end line that three or four strokes of a sharp plane will finish the end, making it smooth and to the line. Use either a block plane or a regular smooth plane. (See Figs. 7 and 7*a*, page 8.) **End planing.**

When the ends are planed, finish the third and fourth faces. This will finish the cross-pieces and the base to the required dimensions. **Putting on cross-pieces.**

The dowel pins are bought in long pieces ready made to diameter and need only to be cut to the required length.

When the stock is all finished to the required dimensions, mark the centre of the pinholes on the cross-pieces. The dimensions will be found in *A* and *B* of Fig. 195*d*. Lay a cross-piece into position on the base-board and clamp both in the vise so that the centre mark for one of the holes is above the vise jaws. With a half-inch bit bore a hole entirely through both pieces. Place a block back of the pieces in the vise to bore into to prevent splitting as the bit comes through. (See Fig. 71*b*, page 56.) (For general information about bits, how to tell the size, etc., see pages 105, 106, and 107.)

After boring the hole and before removing the pieces from the vise, place a pin in the hole to hold the pieces in place. Turn the piece in the vise and bore the other holes in the same way.

The space between the end of the short piece and the edge of the board is left either to the left or right, according to whether a right or left-hand person is to use the hook.

After the holes are made, remove the pins from the holes, put glue on the under side of the cross-pieces and on the pins, then clamp

them in place, as is shown in Fig. 195*g*. The clamp should be left in position for at least twenty-four hours, when the hook is ready for use.

In making the bench-hook the new things we have learned are:

1st. How to state a simple problem by the use of the mechanical drawing.

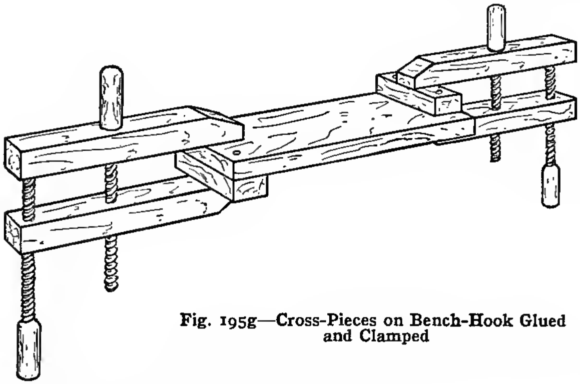


Fig. 195g—Cross-Pieces on Bench-Hook Glued and Clamped

2nd. End planing.

3rd. Something about boring.

4th. What the dowel pin is and one of its uses.

We have reviewed measuring and lining, planing and sawing.

Select one of the problems in the following group for the next exercise.

Group 1

Sharpening tools.

Read carefully what is said about sharpening the plane bit on pages 12 and 13. Practice oil-stoning the bit, but do not grind it until later.

Screw or nail box.

Fig. 196 is a nail or screw box for a bench. From the picture we can see that the pieces required will be as follows:

Two side pieces.

Three cross-pieces.

One bottom piece.

Detail order,

From the mechanical drawing of these parts (Fig. 196*a*) we can get the dimensions and write the detail order as follows:

PINE, POPLAR, OR ANY OTHER SOFT WOOD

2 pieces $\frac{3}{8}''$ x $1\frac{7}{8}''$ x $10''$. . . . . side pieces
3 pieces $\frac{3}{8}''$ x $1\frac{7}{8}''$ x $3''$. . . . . cross-pieces
1 piece $\frac{3}{8}''$ x $3\frac{3}{4}''$ x $10''$. . . . . bottom piece

The side pieces and the cross-pieces are all the same thickness and width, and when combined are only 29″ long. Such a piece is not too long to handle easily and we can get the stock in one piece. Plane to thickness and width, then cut to length. **Mill order.**

If we make that combination and allow $\frac{1}{16}$″ in thickness and $\frac{1}{8}$″ in width, and $\frac{1}{8}$″ for every end cut, the mill order will be as follows:

1 piece $\frac{7}{16}$″ x 2″ x $30\frac{1}{4}$″.
1 piece $\frac{7}{16}$″ x $3\frac{7}{8}$″ x $10\frac{1}{4}$″.

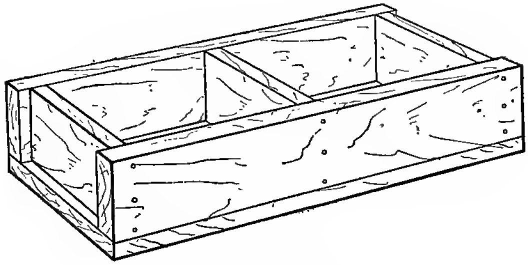


Fig. 196—Nail or Screw Box

To make side and cross-pieces.

Plane the combined side and cross-pieces to thickness and width. Lay out the length by marking entirely around the piece with the knife and try square. (See cross-pieces for bench-hook, page 156, Fig. 195*e*.) If the end cuts are made carefully with a sharp back saw, it will not be necessary to plane the ends of the three cross-pieces and will take but a few strokes of a sharp plane to finish the ends of the two side pieces. Do the end planing against a block, as shown on page 24, Fig. 39*m*.

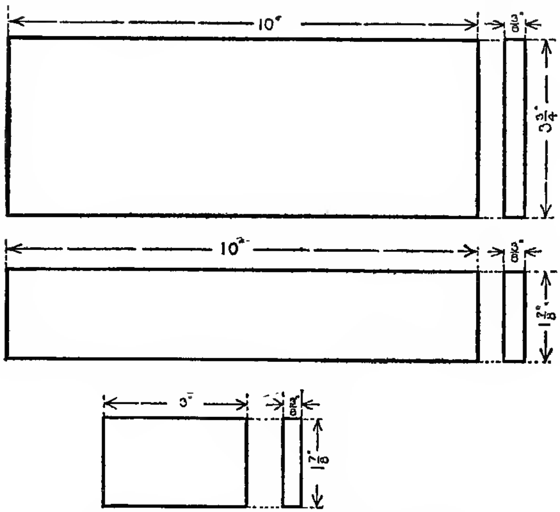


Fig. 196a—Mechanical Drawing of Nail Box Parts

To make bottom piece.

To make the bottom, make the working face and joint edge; saw and plane the

ends to length. (See base-board for bench-hook, page 156, Fig. 195*f*.) After the ends are squared plane the bottom to thickness. The width may be left until the bottom is nailed into place on the box. Then it is planed even or flush with the sides of the box.

Assembly drawing.

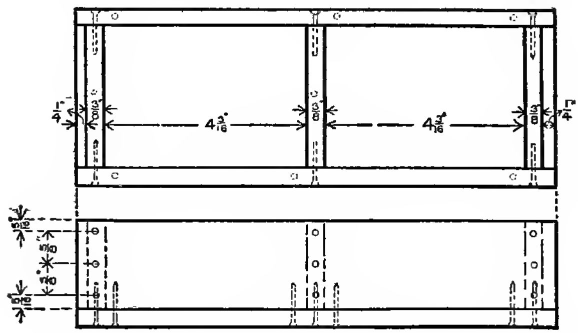


Fig. 196b—Assembly Drawing of Nail Box

Fig. 196*b* is the mechanical drawing of the entire box, showing how the parts are put together. Such a drawing is called an assembly drawing.

Putting the box together.

To assemble the box, mark with a good, sharp pencil the position of the cross-pieces on the side pieces. The position of the brads may be located by a dot made with the gauge. Careful, uniform nailing will give even a rough box a neat, workman-like appearance.

First nail side and cross-pieces together, using $\frac{7}{8}''$ No. 18 brads. (See page 68 for brads and how to order them.) When side and cross-pieces are nailed, nail one side of bottom. Square side pieces with end of bottom and nail the other side and the centre, as shown in the drawing. (Fig. 196*b*.) Set the nails below the surface of the wood. (See nail set and its uses, page 71.) Plane bottom flush with side pieces.

Sand-papering the box.

Sand-paper the entire outside of the box (see pages 118 and 119), using No. $1\frac{1}{2}$ sand-paper over a block, as shown in Fig. 180, page 119. Care should be taken when sand-papering not to round the corners and edges.

When the box is finished write the name on the inside of one of the end pieces.

String Reel

Fig. 197 is the picture of a string reel that may be used for a kite string, a fish line, a chalk line, etc. From the picture we can see that the wood required will be as follows:

Two side pieces.
Three cross-pieces.
Two handle pieces.

From the mechanical drawing of the parts (Fig. 197*a*) we can get the detailed stock order as follows: Detail order.

2 pieces $\frac{3}{8}''$ x $\frac{7}{8}''$ x $8''$ . . . . side pieces
3 pieces $\frac{1}{2}''$ x $1\frac{1}{4}''$ x $3\frac{1}{4}''$ . . . cross-pieces
2 pieces $\frac{5}{8}''$ x $\frac{5}{8}''$ x $1\frac{1}{2}''$ . . . . handle pieces

Mill order.

To save handling so many pieces, we can combine the two side pieces, the three cross-pieces, and the two handles. Making this combination, and allowing $\frac{1}{16}''$ in thickness, $\frac{1}{8}''$ in width, and $\frac{1}{8}''$ for every end cut, the mill order will be:

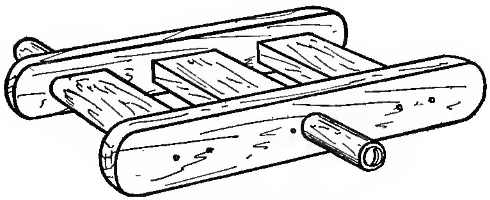


Fig. 197—String Reel

1 piece $\frac{7}{16}''$ x $1''$ x $8\frac{1}{2}''$
1 piece $\frac{9}{16}''$ x $1\frac{3}{8}''$ x $10\frac{1}{2}''$
1 piece $\frac{3}{4}''$ x $\frac{3}{4}''$ x $3\frac{1}{4}''$

Plane all pieces to thickness and width. Saw side pieces to length, leaving one-half the line on the piece you wish to keep. (Note how the cross-piece on the bench-hook was laid out. Page 156, Fig. 195*e*.) With the compasses (see page 88, Fig. 133) lay out the round ends, saw to the lines with the coping saw, or cut to line with a knife. (For the coping saw, see page 98, Fig. 146*b*.) Sand-paper all surfaces Side pieces.

with No. $1\frac{1}{2}$ sand-paper drawn over a block. (For sand-papering, see pages 118 and 119.)

Cross-pieces.

Saw off the centre cross-piece. Before the end cross-pieces are

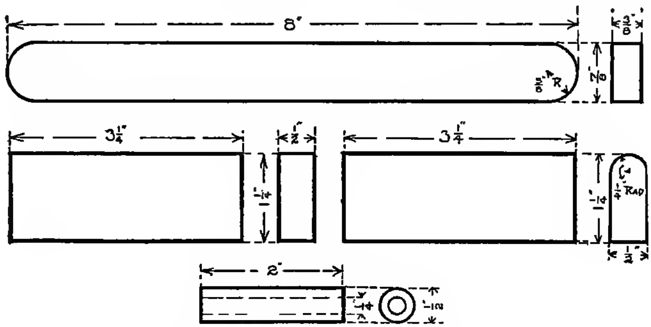


Fig. 197a—Detail Drawing of Parts of String Reel

Making round edges.

sawed apart, draw a half-circle on the ends. Plane the corners down to this line, as shown in Fig. 197*c*, then plane the remaining corners to the line and finish by clamping one end in the vise and drawing a strip of sand-paper over the edge, as in Fig. 181, page 120.

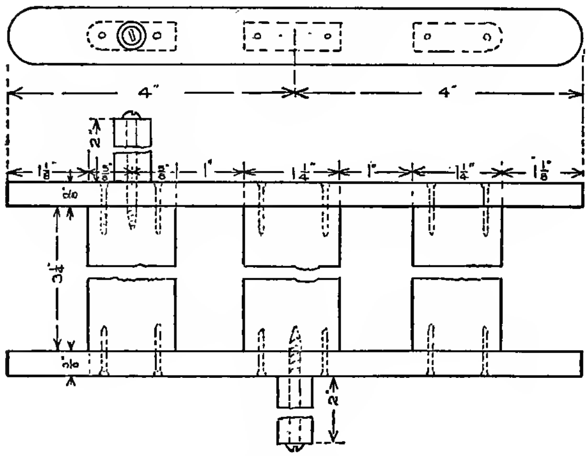


Fig. 197b—Assembly Drawing Showing How the Parts of String Reel Go Together

Handle pieces.

Saw the pieces to exact length. It will not be necessary to plane the ends. Make a circle on the end of the handle piece, plane the corners to the circle, then plane the remaining corners. Finish round with sand-paper. Saw to

length, clamp in vise and bore a hole large enough for a No. 12 round-head screw.

Fig. 197*b* is a mechanical drawing showing how the parts are put together. If we remember that the lines which cannot be seen are shown as dotted lines, the drawing will not be hard to understand. Assembly drawing.

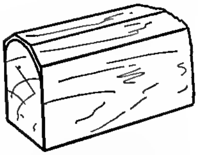


Fig. 197c—End Cross-Piece Laid Out for Rounding Edges

Use $\frac{7}{8}''$ No. 17 brads. (See page 68.)

Fasten the handles on with $2\frac{1}{2}''$ No. 12 round-head screws. (See page 72.)

When the piece is finished write the name carefully on the flat side of the centre cross-piece.

Problems

No. 1. Write the detail order for the stock in a box 6″ deep, $8\frac{1}{2}''$ wide, and 12″ long, outside dimensions, all the stock to be $\frac{1}{2}''$ thick. The box is to be constructed the same as the nail or screw box (Fig. 196), with the end pieces set in the same distance from the end of box.

No. 2. Measure a window-sash or a screen frame and write a detail order for the stock.

Remember that in the detail order no stock is allowed for finishing.

Group 2

The Lap Joint

Problem No. 1

The first problem in this group will be the half lap joint, the picture of which is shown in Fig. 40. From the experience we have had with reading a mechanical drawing in the first group we can read at once the statement of the problem as given in the drawing.

Begin with "The Problem of the Lap Joint" stated, page 66, and make a lap joint as instructed. Follow closely the method of laying

out the joint and the use of the tools. (Pages 35 to 47, inclusive.) Several new tools and operations are used in this joint, and it will require careful attention to master them.

Problem No. 2

Detail and assembly drawing together.

Each member of the class will make a lap-joint frame as in Fig. 198. In Group No. 1 we made a drawing of each piece separately and the assembly drawing to show how the pieces were put together. This method takes too much time and space, so the mechanic usually makes only the assembly drawing and puts in the dimensions of each piece, as they occur in the drawing. If any part of a piece is complicated, the drawing of that part is often set out by itself as is the corner of the picture-frame (Fig. 198*b*), and the detail dimensions of the part thus set out are omitted in the assembly drawing.

Special detail drawing.

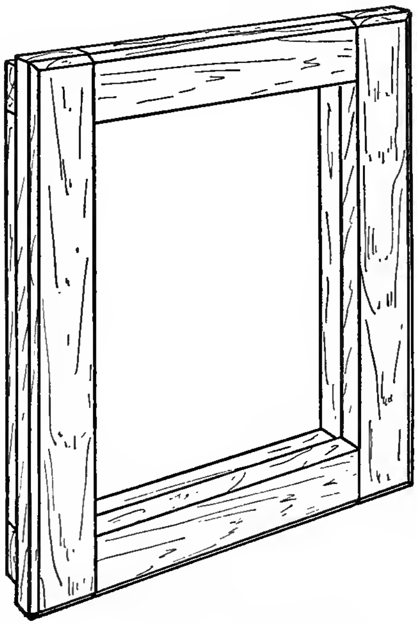


Fig. 198—Lap-Joint Picture-Frame

The number of parts and figures so near together do not need to confuse the beginner, and will not if he remembers that the frame is made of single pieces of wood, all of which have thickness, width, and length.

Reading the drawing.

To read the mechanical drawing for the picture-frame and write the detail order for the material, select any piece, say the side strip (*A*, Fig. 198*a*); the thickness will be found on some part of the drawing (Fig. 198*a*), where the end or an edge of the side piece is shown, as, for example, at the top of the edge view we find the thickness to be $\frac{3}{8}''$.

The width we shall find where a flat side or an end of the piece is shown, as at the top of the face view we find $1\frac{5}{8}''$ to be the width.

The length will be found on the face or an edge view. Thus we have found the three dimensions of the side strip, and since there are two of them the order for them will be:

2 pieces $\frac{3}{8}''$ x $1\frac{5}{8}''$ x $12\frac{3}{4}''$

In the same way find the dimensions and write the order for the remaining parts of the frame. In doing this note the arrow points and figures carefully to make sure that they mark the desired dimensions.

Write the mill order for stock, allowing material for finishing, and combine the parts to save time in working to dimensions. Do not make any combination of parts which are longer than 30″. Mill order.

When the materials are at hand, plane all to thickness and width. Lay out and cut to length, allowing $\frac{1}{8}''$ on each projecting end for finishing, after the pieces are put together, the same as in making the lap joint.

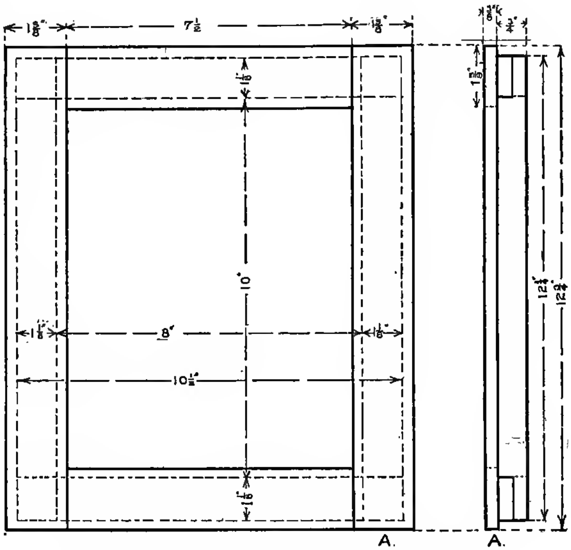


Fig. 198a—Mechanical Drawing of Lap-Joint Frame

No end planing should be done until the parts are put together, for the ends of all the pieces are either covered or are backed up by some other piece so that end planing is made easy. End planing.

The lap joint for the corners of the frame is given in the detail drawing of the corner (Fig. 198*b*), and is called an end lap joint. (See page 58, Figs. 73 and 73*a*.)

Corner joints.

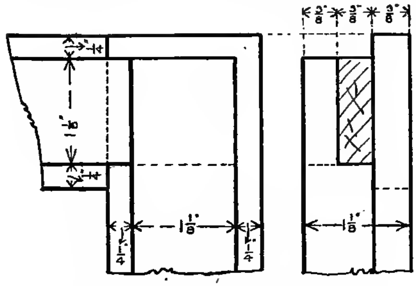


Fig. 198b—Detail of Picture-Frame Corner

Lay out the joints the same as part No. 1 of the lap joint, Problem No. 1, group 2. (See pages 37, 38, and 39.) If the material for the joint is cut from the working face in the end pieces, it should be cut from the opposite face for the side piece. (See page 46 for the reason.) Be sure to keep all working edges and faces marked, and use them as directed in laying out all lines with square and gauge.

Saw to all lines both across and with the grain, leaving one-half the line on the part you wish to keep. No chiselling of surfaces should be necessary.

When the parts are made, put a little liquid glue on the joint surfaces and nail together with $\frac{5}{8}''$ No. 17 brads.

Assembling frame.

Glue top strips into position. Use clamps as for bench hook, see page 158, Fig. 195*g*. Let the clamps remain on the pieces at least twenty-four hours. When dry, remove clamps and nail the strips from the back with 1″ No. 17 brads. This will help hold the glued joints.

Bevel edges.

To improve the appearance, cut a small bevel all the way around the edge. The bevel is not shown in the mechanical drawing, but should be $\frac{1}{4}''$ on the face and $\frac{1}{8}''$ on the edge. (Note what is said on page 82 about laying out bevelled and round edges. Lay out the bevel lines with a sharp, hard pencil. Plane to the lines with the smooth plane, cutting the ends from the edges toward the centre to avoid splitting the corners.

Sand-papering.

Sand-paper all outside surfaces with sand-paper drawn over a block.

The lines should be straight, the bevel uniform, and the corners sharp and square.

Finish the frame to match the picture to be put into it. **Finish.**

See Chapter VI for wood finishing.

The picture and the glass are held in place by a thin piece of board or pasteboard fastened on the back.

By slightly modifying this frame it may be made as a print frame, or the same corner joints may be used on a window-screen frame. **General statement**

The following problems will furnish further application of the principles learned thus far, and will introduce a few new tools and operations, which will be explained as they are used.

Each pupil should do at least two of the smaller problems or one of the larger ones, including the shelf, or pupils may choose a problem of their own similar to these, provided they make a drawing of each part, giving all the necessary dimensions, and one showing how the parts are put together, as was done in Group No. 1.

Begin each problem by writing a detail order for the material or stock.

Write a mill order allowing material for finishing. Group similar parts in the mill order when it will aid in getting the stock to the required shape. Be sure, however, to add enough material to allow for extra cutting. Usually $\frac{1}{8}''$ for every end cut will be enough.

Never lose sight of the necessity of doing careful work.

Lay out all parts and check them in some way before cutting.

Always measure and make lines with the proper tools and in the proper way.

Windmill Made of Soft Wood

The only new operation is cutting the bevel on the fan pieces, which will be done after they are planed to dimensions and the middle lap joint made at the centre. As shown by the picture and the **Fan piece.**

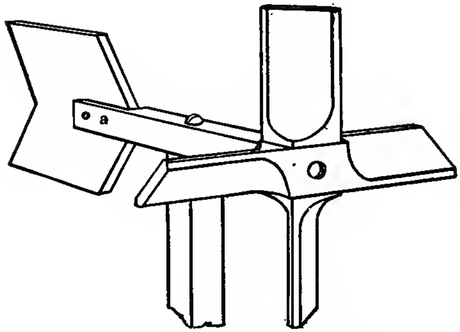


Fig. 199—Windmill Made of any Light, Soft Wood

mechanical drawing, the bevel is made diagonally across the corners, opposite diagonals being used on opposite ends of each piece. Lay out the fan pieces with a sharp pencil by drawing the lines *A A*, (Fig. 199*b*) $\frac{3}{16}''$ each side of the corner. Connect these lines with a diagonal line across the ends. Draw the lines *B B* as shown in the drawing. Be sure to use opposite corners when laying out the ends of each piece.

When all the lines are laid out, clamp a piece in the vise and saw to all the lines *A A*, then saw to the lines *B B*. Finish the sawed surface with a chisel and sand-paper.

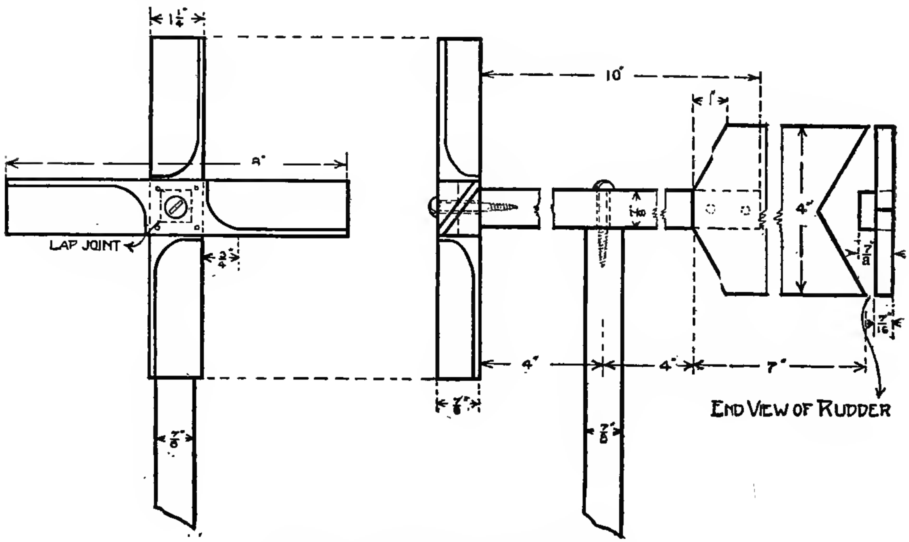


Fig. 199a—Mechanical Drawing of Windmill

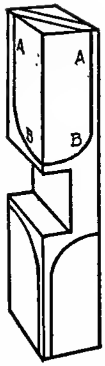


Fig. 199b—Fan Piece Laid Out for Sawing

Assemble the parts as shown in the drawing.

Make the length of the standard to meet requirements.

Wall Rack

Make the wall rack of soft wood, but choose the kind of wood and the finish to meet the requirements of service.

Choice of materials.

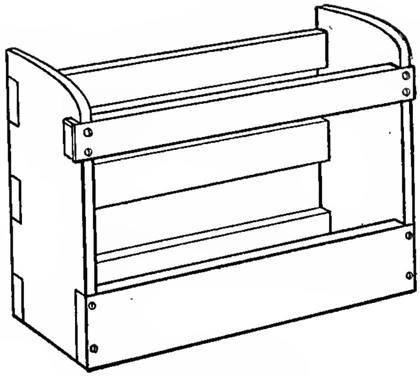


Fig. 200—Wall Rack

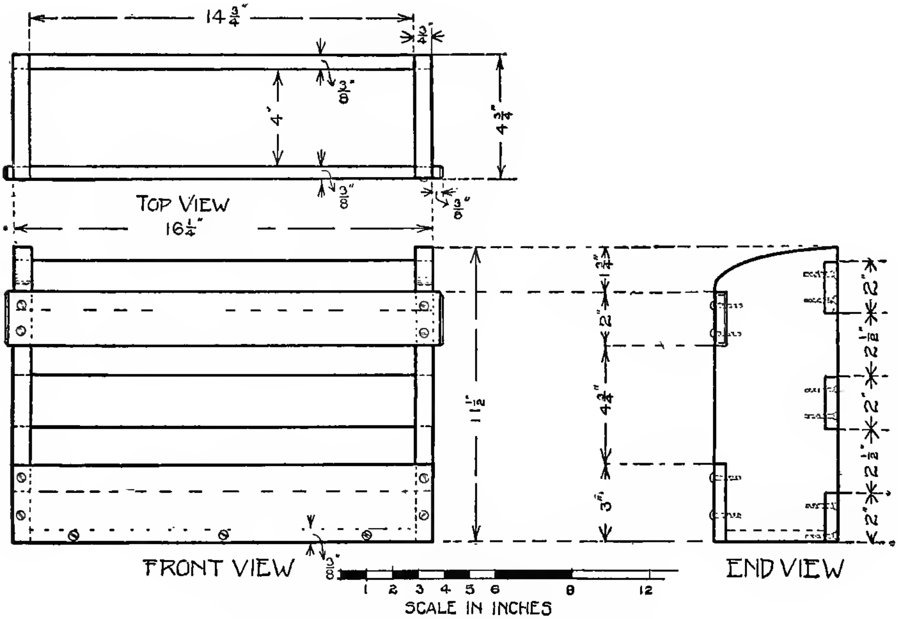


Fig. 200a—Mechanical Drawing of Wall Rack

Making curves on side pieces.

The only new feature is the curves made at the top of the end pieces. The curves are made after the end pieces have been cut to dimensions and are merely to give the rack a more pleasing appearance. Such curves must be laid and cut out carefully or they will not look well.

First, lay the curve out on a piece of thick paper or card-board. Cut it out and trace with a pencil on the end pieces. Saw to the line with a coping saw. (See page 98.) Finish curves with spokeshave (see page 101), and with sandpaper drawn over a block. Assemble the parts as shown in the drawing.

Doll Cradle

The cradle is made of soft wood and finished with the mahogany stain (see page 126) to make it bright and attractive. This cradle is

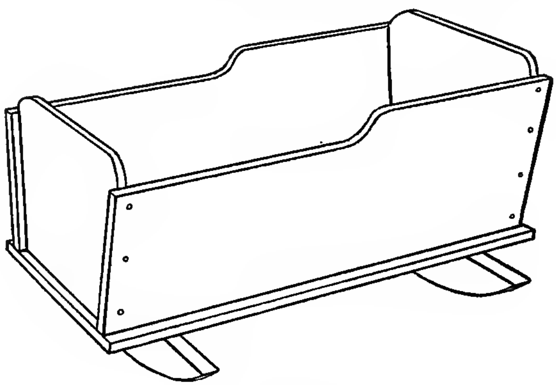


Fig. 201—Doll Cradle

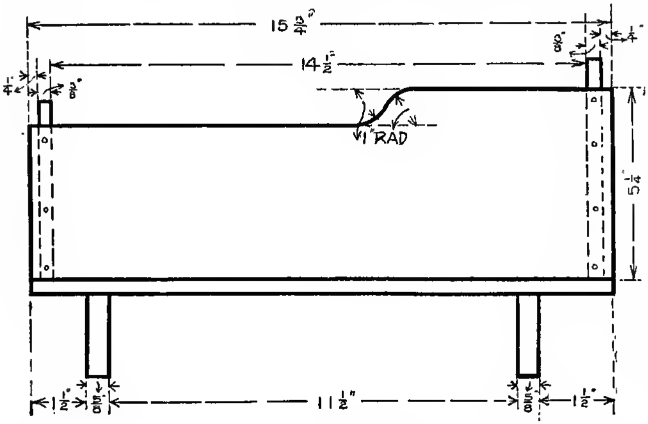
made for a doll twelve inches long. You may change the dimensions to fit the doll that is to use it.

Bevel.

The new feature in the doll cradle is the use of the bevel to lay out the slanting lines on the end pieces.

Order the stock. Plane the end and side pieces to the largest dimensions. Use the compasses (see page 88) to lay out all the curves indicated in the drawing.

Lay out the lines on one of the head pieces as shown in Fig. 201*b*. With the beam of the bevel (see page 87) on *B*, set the blade to the line *A*. Then, with the bevel used the same as a square, draw all the other slanting lines on the head and foot pieces. **Head piece.**



Saw to the curved lines with the coping saw (see page 98) and to the slanting line with the back saw.

Fasten side and end pieces together as indicated; then carefully plane the bottom edge of the side pieces square with the bottom of the end pieces. **Assembling parts.**

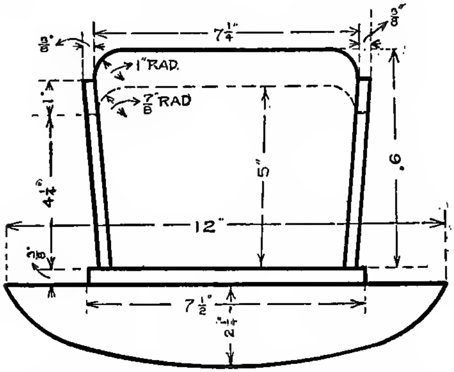


Fig. 201a—Mechanical Drawing of Doll Cradle

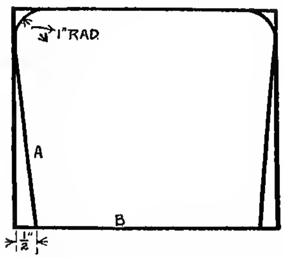


Fig. 201b—Bevel Laid Out on End Piece

Nail the bottom to the sides and screw through the bottom to hold the rockers.

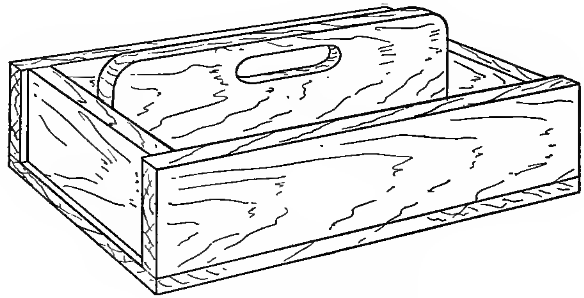


Fig. 202—Tool or Knife Tray

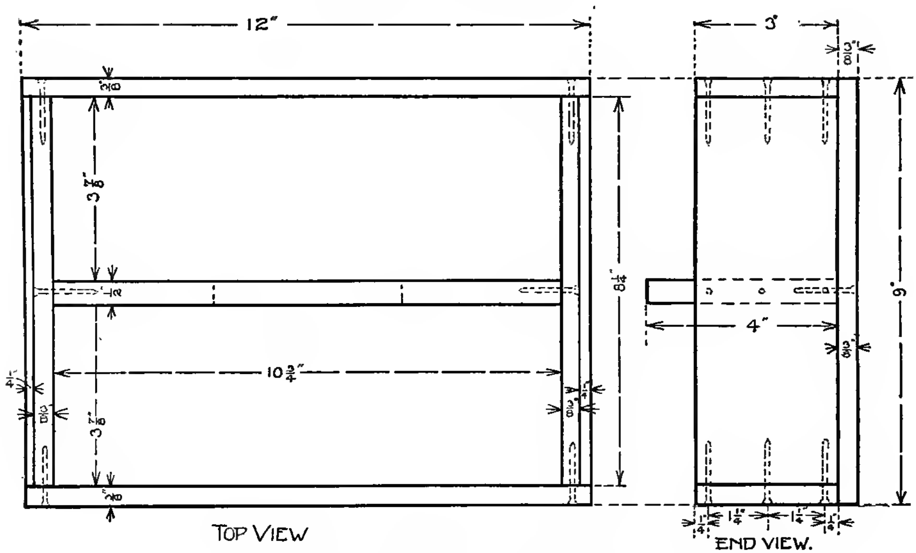


Fig. 202a—Mechanical Drawing of Knife Tray

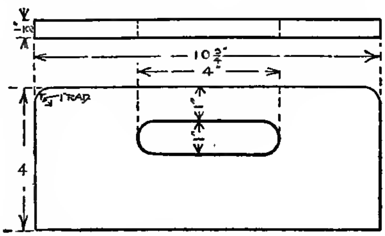


Fig. 202b—Detail of Centre Piece of Tray

Tool or Knife Tray

The drawings of the tool or knife tray (Figs. 202, 202*a*, and 202*b*) give a full statement of the problem. The dimensions given are for a knife tray. If you want to make a tool tray, copy the drawings and change the thickness of the wood and the other dimensions so as to make it strong and large enough to meet your requirements.

The corner curves are marked with compasses and cut out with the coping saw the same as the other curves.

To cut the hand hole in the centre-piece, mark the position of the hole with the gauge and compasses. Bore holes with a 1″ auger bit to make the end curves. Saw to the side lines with the compass saw (see page 98). Finish the edges and break the sharp corners of the hole with sand-paper, as in Fig. 181, page 120.

Assemble the box as shown in the drawing (Fig. 202*a*) and finish to meet the requirements.

The Shelf

All pupils should design and make a shelf. A shelf is usually made to occupy some special place and to hold some particular object or objects. The mechanical requirements are that the shelf be large enough to fill the space and strong enough to hold the objects to be placed upon it. **Object of shelf.**

Fig. 203 shows a shelf which meets the mechanical requirements, except, perhaps, that the square corners of the bracket—that is, the pieces which support the shelf—are in the way. In that case the bracket could be cut off, as in Fig. 203*a*. In both cases we have a strong shelf which can be made to any reasonable size; but should we care to give them a better place than in the barn or shed?

There is, indeed, something lacking when we consider either shelf for a place in the home. In other words, they meet all of the **Use and beauty.**

requirements of a shelf but do not meet the requirements of a piece of furniture.

Bracket curve.

To make the shelf meet the requirements of a piece of furniture we must not take away any of its usefulness.

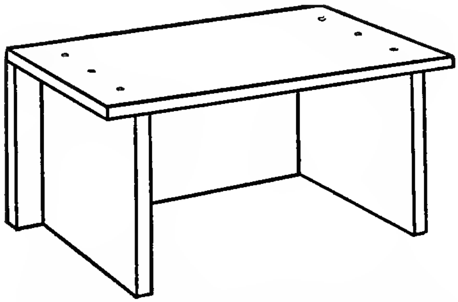


Fig. 203—Shelf Which Meets All Mechanical Requirements

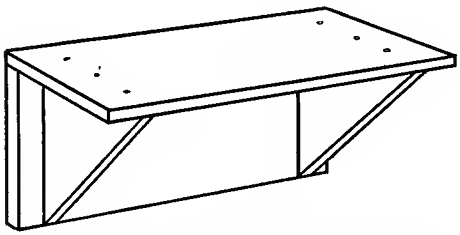


Fig. 203a—Shelf with Corners of Bracket Cut Off to Save Space

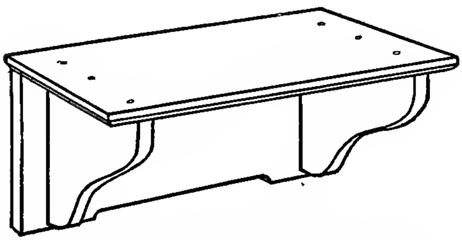


Fig. 203b—Shelf Suitable for a Piece of Furniture

Suppose we make the change in the bracket as suggested in Fig 203*b* or as shown in the mechanical drawing. (Fig. 203*c*.) The curves seem to add strength to the bracket as compared to the straight lines in Fig. 203*a*.

The dotted lines in the end view of the mechanical drawing (Fig. 203*c*) suggest curves which might be made in place of the one used.

Bevelled edges.

The slight bevel on the lower edge of the shelf and the small curve in the back-board seem to add something pleasing that is not found in the sharp, unbroken lines of the other shelves. Thus, in making a piece of furniture out of a mere shelf we have added lines and curves which make it pleasing to look at and at the same time have not taken away any of the requirements.

Various curves and their uses.

The ends of the side pieces of the string reel (Fig. 197) are rounded

to keep the string from catching. The ends of the cradle (Fig. 201) are rounded to break the sharp corners and allow for added height. The handle hole in the centre piece of the tool box (Fig. 202) has a mechanical value as a handle, and for that reason does not appear

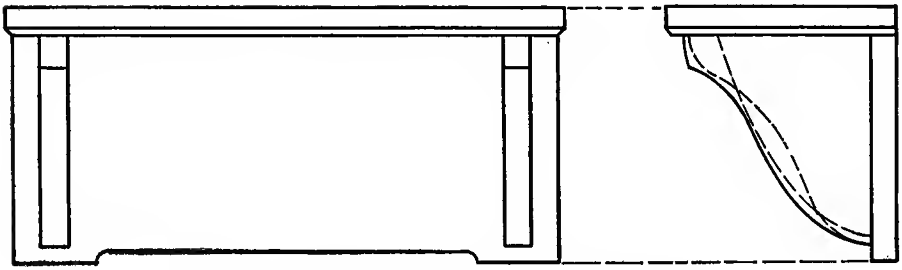


Fig. 203c—Mechanical Drawing of Shelf, without Dimensions

out of place or ill-shaped. The curves and bevel on the shelf give variety to the straight lines. In general, it may be said that, if added lines or curves are a true decoration, we must feel that to remove them would take something away from the usefulness of the object. General statement.

The problem is to make a shelf to meet your own requirements. The problem.

Make a drawing of all the parts; put in all dimensions and order the stock, as in the previous problems.

Problems

Lumber is sold by the square foot. A board one inch thick and one foot square contains a board foot of lumber.

To get the number of board feet in any piece of lumber, multiply the thickness expressed in inches by the width and length expressed in feet.

Problem No. 1

How many board feet of lumber in a board 1″ x 6″ x 12′? Rewriting the problem and expressing the width—6″—in feet, we have 1″ x $\frac{1}{2}$′ x 12′. Multiplying the thickness, width, and length, we have 6 board feet as the answer.

Problem No. 2

How many board feet in a board 2″ x 4″ x 10′? Reducing the width to feet, we have 2″ x $\frac{1}{3}$′ x 10′. Multiplying the thickness, width, and length, we have $6\frac{2}{3}$ board feet as the answer.

Problem No. 3

How many board feet in a board $\frac{1}{2}$″ x 7″ x 9′?

Note.—It is becoming a general custom to quote prices of lumber less than an inch in thickness by the square feet of surface. In that case the square feet obtained by multiplying the width in feet by the length in feet will be the number of board feet required.

Problem No. 4

How many board feet of lumber in the following bill of lumber?

3 pieces 2″ x 4″ x 10′
2 pieces 1″ x 5″ x 12′
5 pieces $\frac{1}{2}$″ x 3″ x 9′

Problem No. 5

Measure the floor in a room at home or at school and figure the cost of the lumber if the flooring costs $60.00 per 1,000 feet.

Group No. 3

Mortise and tenon joint.

The first problem in the group will be to make the through mortise and tenon joint given in Chapter III, pages 48 to 56, inclusive.

All pupils are to make this joint.

Follow carefully each step as it is given. Note particularly the method of laying out the joint.

Cut the mortise with a chisel, but note the use of the auger bit for removing the surplus stock from the mortise.

This type of joint is used in all manner of construction and is very important, consequently it should be given close attention.

Clothes Hanger and Tie Rack

Problem No. 2

Make of hard or soft wood and finish to meet the requirements of service.

Each pupil should make either the clothes hanger or the tie rack.

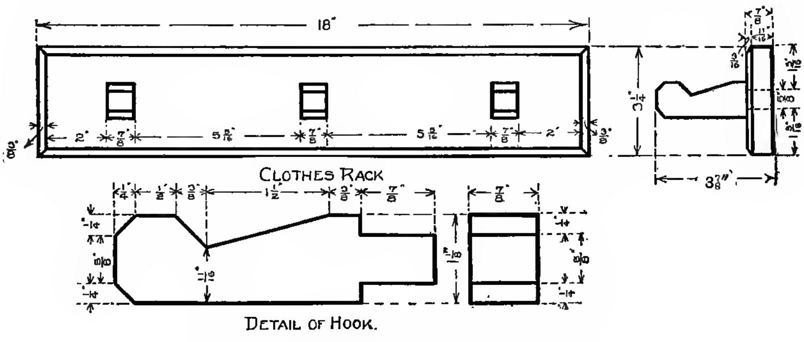


Fig. 204—Mechanical Drawing of Clothes Hanger

Statement of problem.

The mechanical drawings give a full statement of the problems. Write the detail and mill orders for materials. Figure the amount of

General directions.

lumber and the cost at the market price in your locality. Lay out and cut the mortise before the edges are bevelled, in order to have a square edge to work from. The mortise should be laid out on both

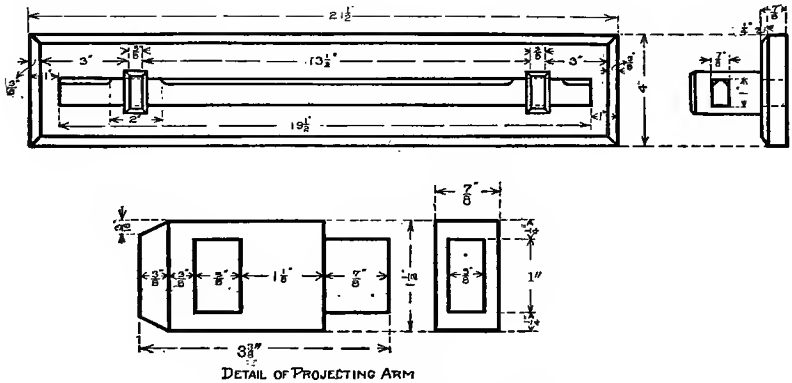


Fig. 205—Mechanical Drawing of Tie Rack

sides of the base piece. (Note how the mortise was laid out on both sides of the piece on pages 49 and 50.) Make all lines for bevelled edges with a pencil. (See page 82.)

Remember that to look well all bevelled edges must be made straight and uniform.

A Set of Balances

Make of either hard or soft wood and finish to protect the wood.

The set of balances, the mechanical drawing of which is given (Fig. 206), is not a toy but a useful instrument which may be used in a school laboratory. If reasonable care is taken in making them the balances will weigh accurately to a centigram.

Scale pans

The scale pans are made of the pressed tops of tin cans such as are used on paint cans.

The wire by which the pans are suspended is ordinary galvanized iron wire about the size of that used for a telephone.

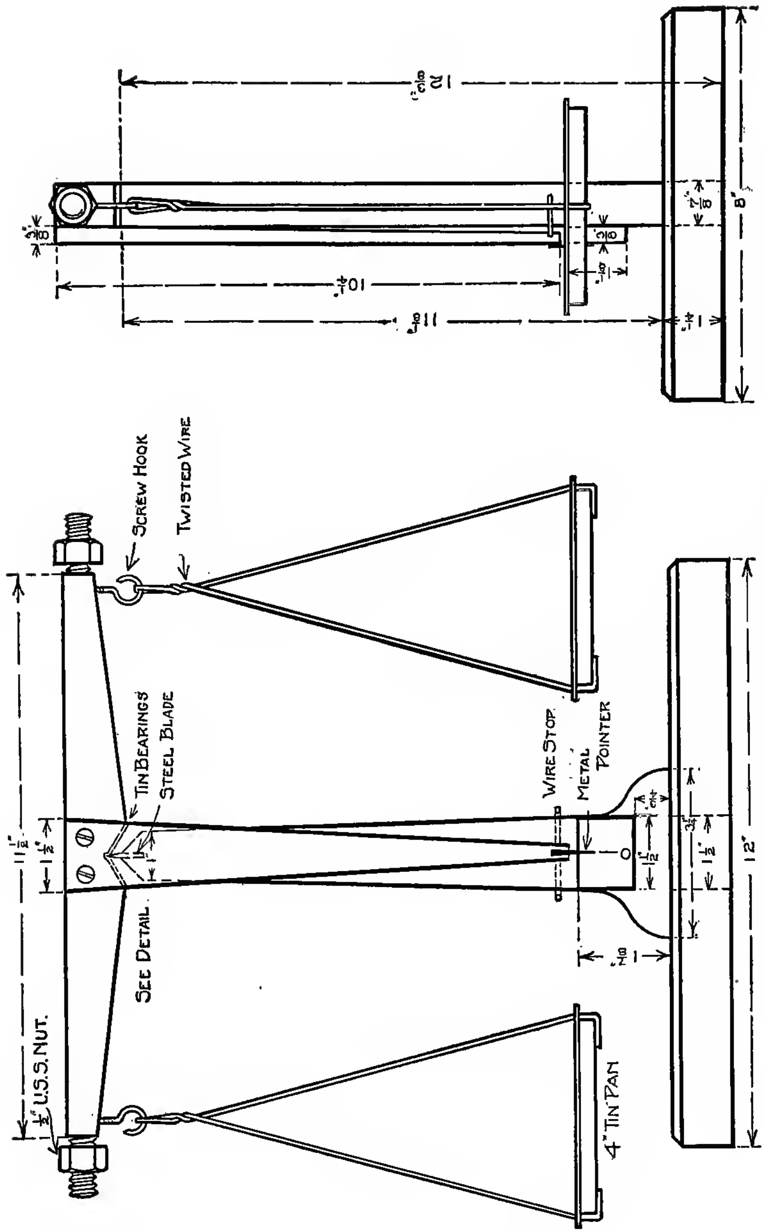


Fig. 206—Mechanical Drawing of Balances

The screw hooks can be obtained at any hardware store.

Counter poise.

The nuts on the ends of the balance arm are for a counter poise, and by turning them in and out the pointer may be made to stand at the zero point. Any ordinary nut will do.

Cut the wood round, almost to the size of the hole in the nut. Screw the nut on. It will cut its own thread.

Pivot-bearing.

Fig. 206*a* is a detail drawing of the pivot-bearing for the balances.

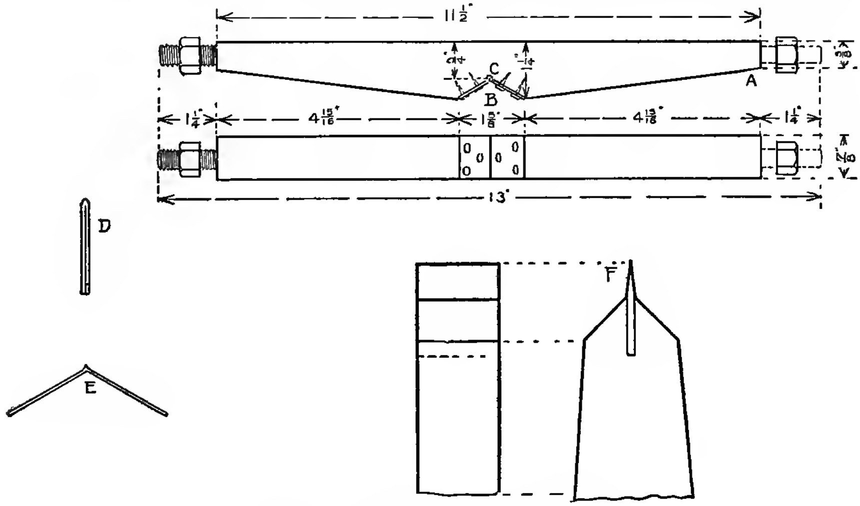


Fig. 206a—Detail of Pivot-Bearing for Balances

After sawing out the place (*B*, Fig. 206*a*) for the bearing post, take a stroke of the saw where the cuts meet at *C* to make the corner sharp.

Cut out a piece of tin as wide as the balance arm (ordinary house shears will cut tin) and of the required length. Fold the tin as at *D*, Fig. 206*a*, and flatten the fold with a hammer but not enough to break the metal. Spread out the two parts of the tin as in *E*. The sharp fold will make a crease in which the metal bearing (*F*) will fit.

F is a piece of steel (a broken knife blade will do) driven into a saw cut. All other details are given in the drawings.

Umbrella Stand

To make the umbrella stand (Fig. 207) order materials as usual. Make all parts to the required dimensions, being careful to make and mark a working face and joint edges on all pieces.

To lay out mortises.

Lay out the mortises on the working face and joint edges, for those faces are made especially square and accurate.

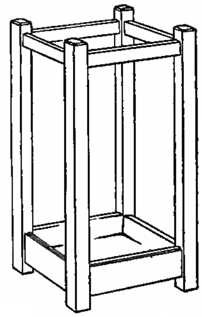


Fig. 207—Umbrella Stand

First locate and make the end lines of all the mortises; then set the gauge and make the lines on one side of all the mortises. Add the thickness of the mortise to the first setting of the gauge and draw all the lines for the second side. Be sure to keep the head of the gauge on the working face and the joint edge. Locate and draw the shoulder line of all the tenons.

To lay out tenons.

Make all the lines on one side of all the tenons. Reset the gauge and make all the lines on the other side. Remove stock for mortises with auger bit. (See pages 55 and 56.) Use a bit stop similar to the one shown in Fig. 171, page 109, or make a stop of a block of wood.

To make mortises.

When all mortises are bored, cut to the line with a chisel as in making the through mortise and tenon joint. (See page 54, Figs. 70*h*, 70*i*, and 70*j*.)

Be sure to make the sides of the mortises straight. Test by standing the edge of the chisel against the sides and note if the chisel is square with the face of the piece.

To make tenons.

When the mortises are all made, make the tenons. Saw the lines with the grain first; the reason for this will be evident. Then saw the shoulder lines. If care is taken in sawing, very little chiselling will be necessary.

Assemble the parts as shown in the drawing. Glue two of the

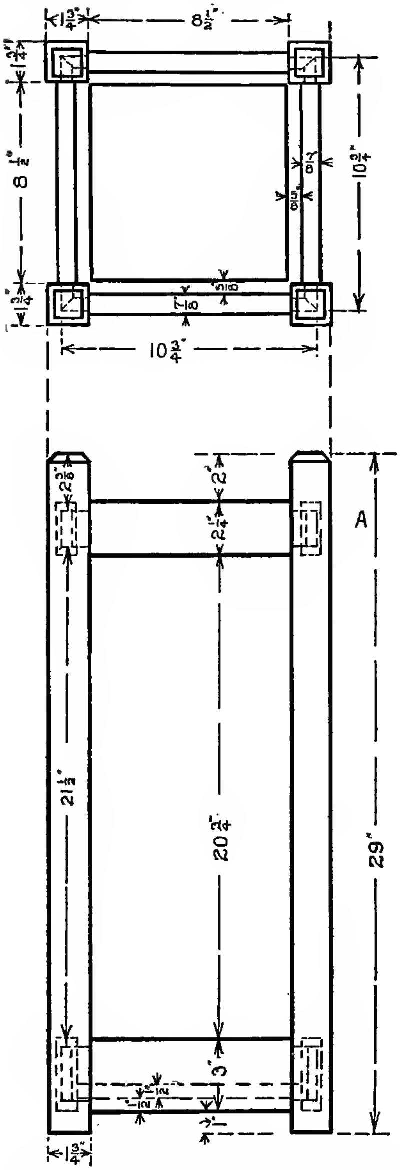


Fig. 207a—Mechanical Drawing of Umbrella Stand

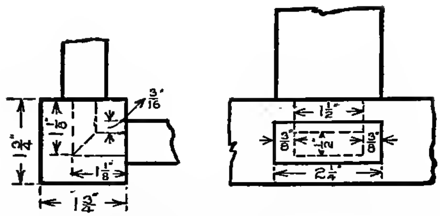


Fig. 207b—Detail of Joint A, Umbrella Stand. Lower Corner Identical with Exception of Tenon 2½" wide and 3" cross piece.

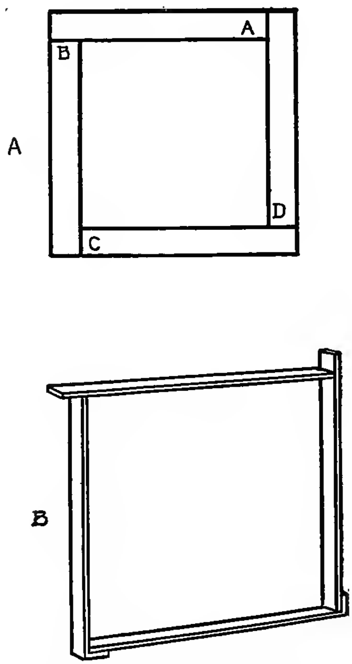


Fig. 207c—How to Lay Out and Make Pan for Umbrella Stand

sides together first; when in the clamp, test to make sure they are square. The next day glue the cross-pieces between these two sides and test for squareness again. Clean off all surplus glue with a damp cloth or waste before it hardens. When the glue is hard, put in the bottom, as shown in the drawing. Scrape, sand-paper, and finish to meet the requirements of the wood and service. Make a shallow metal pan for the bottom, as shown in Fig. 207*c*. Take a flat piece of copper, zinc, or galvanized iron, lay out the size of the bottom with a knife or pencil, as shown in *A*, Fig. 207*c*. Slit the corners *A B C D*. Clamp a block on both sides of the metal and bend up the edges, as in *B*, Fig. 207*c*. Bend the metal at the corners around the sides and solder to hold any water that may run from a wet umbrella.

Removing surplus glue.

How to make metal pan.

Group No. 4

The problems should be fully stated, the materials ordered, and the costs figured, the same as in the preceding groups.

The pupil should begin to grind his own chisels, and when skilful enough to do good chisel grinding he may begin to grind his plane bits. (See "Grinding Plane Bit," pages 12 and 13, Figs. 15 to 20.)

Tool grinding.

Learn the difference between the crosscut and the rip saw and the reasons for the difference. (See pages 5 and 6.)

Learn to select saws.

Each pupil should make at least one article in the group from rough lumber, doing all the rough sawing and planing. (See page 4, Figs. 1 and 1*a*, for laying out rough dimensions, and pages 6 and 7, Figs. 6 and 6*a*, for starting the rip and the crosscut saw.)

Tabouret

In making either of the tabourets (Figs. 208 and 209), or any substitute, we must take into consideration the plant which is to be placed upon it and the place which it is to occupy in the room. Neither of

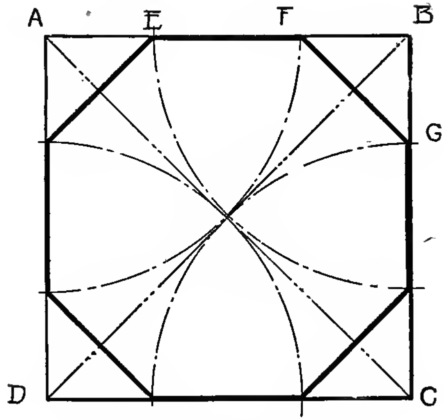


Fig. 208a—How to Lay Out an Octagon

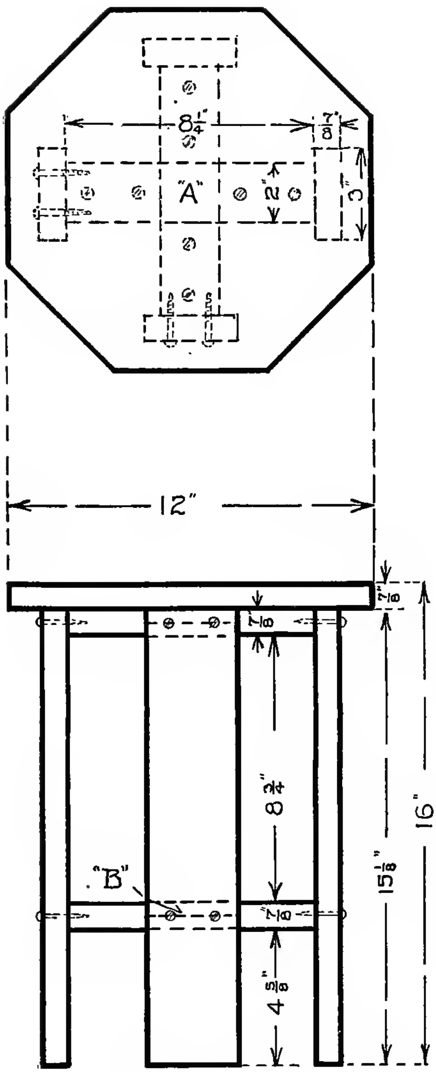


Fig. 208—Tabouret

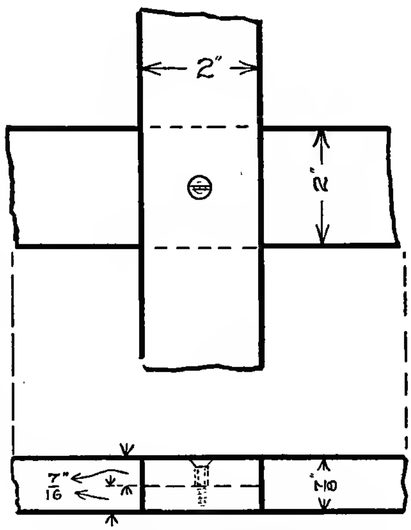


Fig. 208b—Detail of Cross Lap Joints "A" and "B" Fig. 208

the tabourets given would be suitable for a wide-spreading plant, for the plant and stand would be top-heavy.

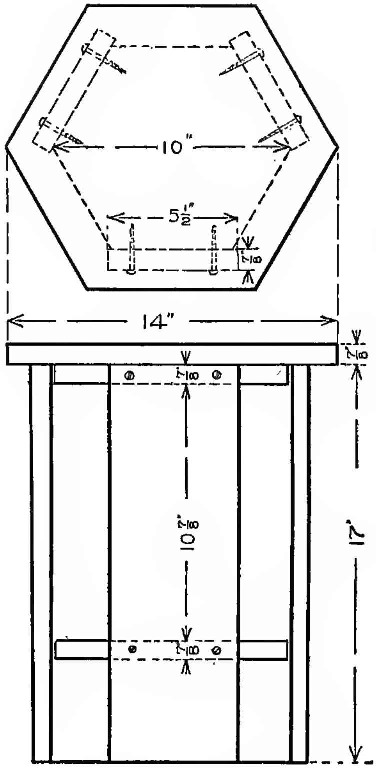


Fig. 209—Tabouret

Scales

The scales (Fig. 210) are a useful article and will weigh accurately to five grams. The pivot-bearing is made the same as the pivot-bearing for the balances (Fig. 206*a*). The sliding weight on the arm is a block of wood which weighs one gram. It slides on a galvanized iron wire about the size of a telephone wire. The weight pan (*B*) is made from a tin can top, which is also hung on a small galvanized-iron wire.

General information.

A block of lead is fastened to the bottom of the scale pan to make a counter poise for the long arm. All other details are given in the drawing.

Saw Horse

The saw horse (Fig. 211) may be made to meet almost any requirement. The mechanical drawing is a complete statement of the horse as it is given.

The Loom

Figs. 212, 212*a*, 212*b*, 212*c*, etc., give the drawings of a small loom. This is a very efficient loom and is a good problem for a group of pupils to make for a class that is studying textiles.

Good class problem.

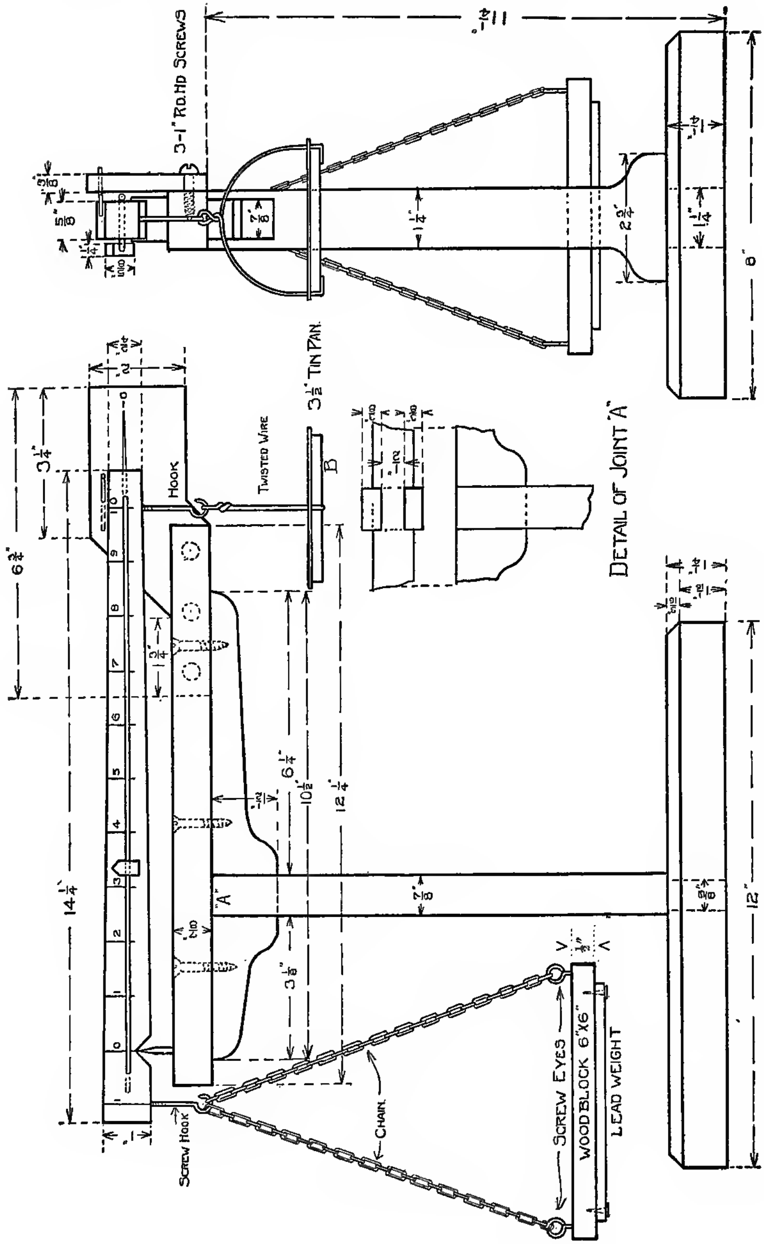


Fig. 210—Scales

The assembly drawings seem rather complicated, but a glance at the detailed parts will show that while there are a number of pieces they are very simple and will build up rapidly.

The slats (*A*) on the heddle (Fig. 212*c*) are made straight on the edges and nailed into position. A piece of No. $1\frac{1}{2}$ sand-paper is folded Heddle.

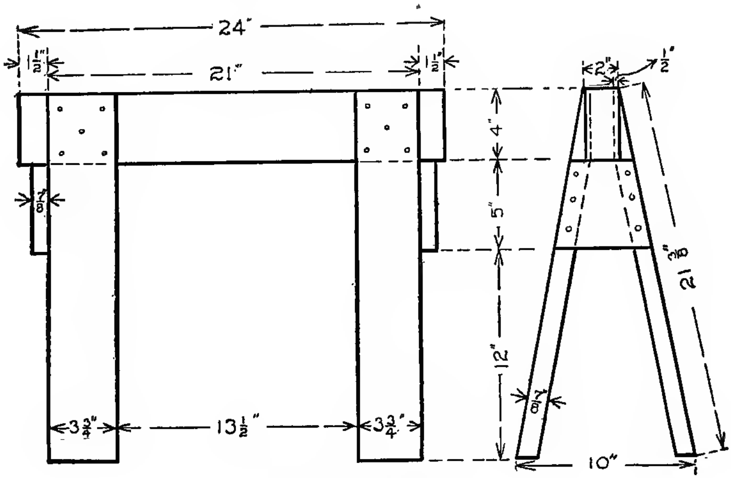


Fig. 211—Saw Horse

with the sand out and is drawn back and forth between the slats. This will round and smooth the corners as at *B*.

To make the batten (Fig. 212*d*) make a line with the gauge in the centre of the cross-pieces. Mark the places for the nails with the dividers. To prevent splitting, clamp the top cross-piece firmly in the vise and drive in the nails. Remove the piece from the vise and nail crosswise, as at *C*, *D*, etc., Fig. 212*d*. Clamp the piece in the vise again, with the nail points up, and straighten the nails either with the hand or a pair of pliers. Then clamp the lower cross-piece in the vise and drive the nails into it. Batten.

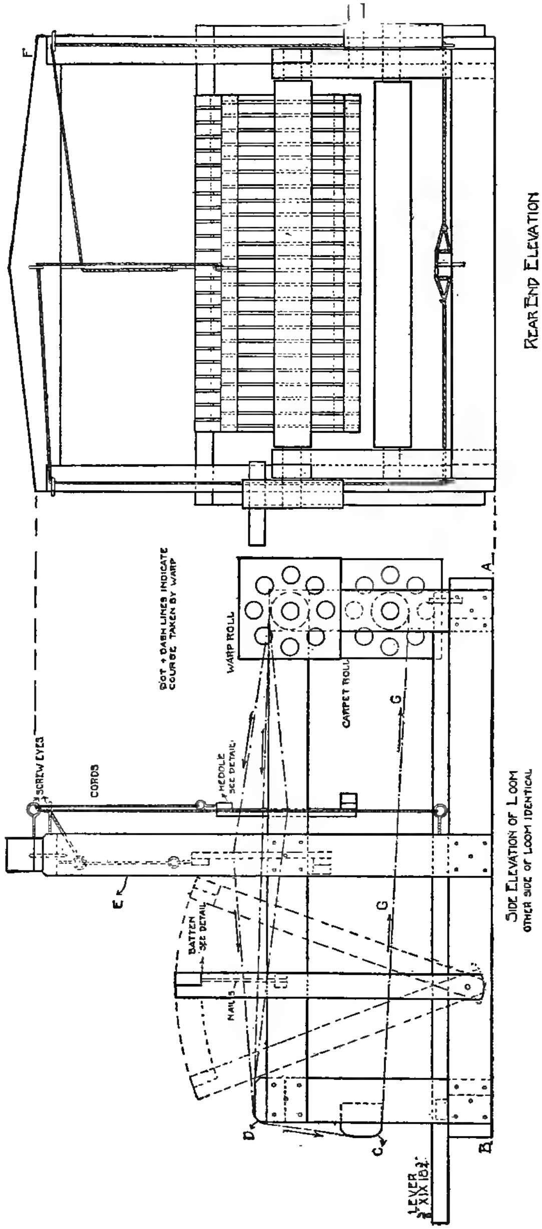


Fig. 212—Assembly Drawing of Loom

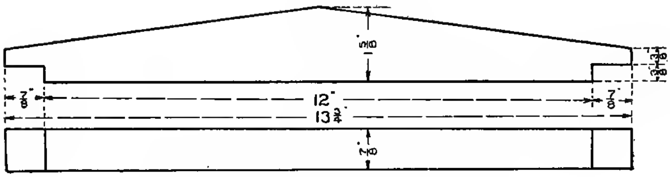


Fig. 212a—Cross-Piece "F." One Piece

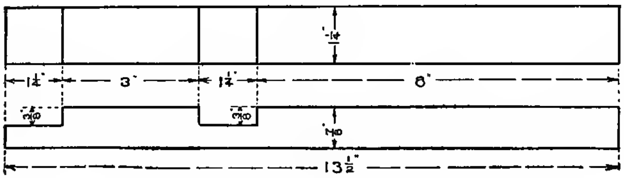


Fig. 212b—Upright "E." Two Pieces

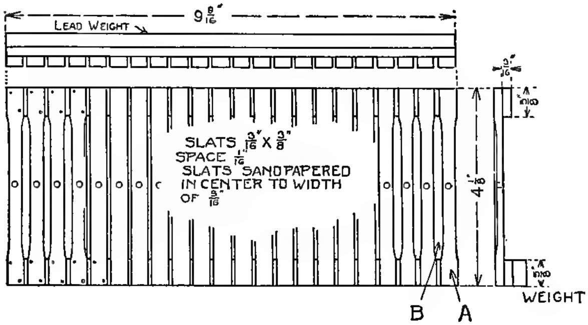


Fig. 212c—Detail of Heddle for Loom

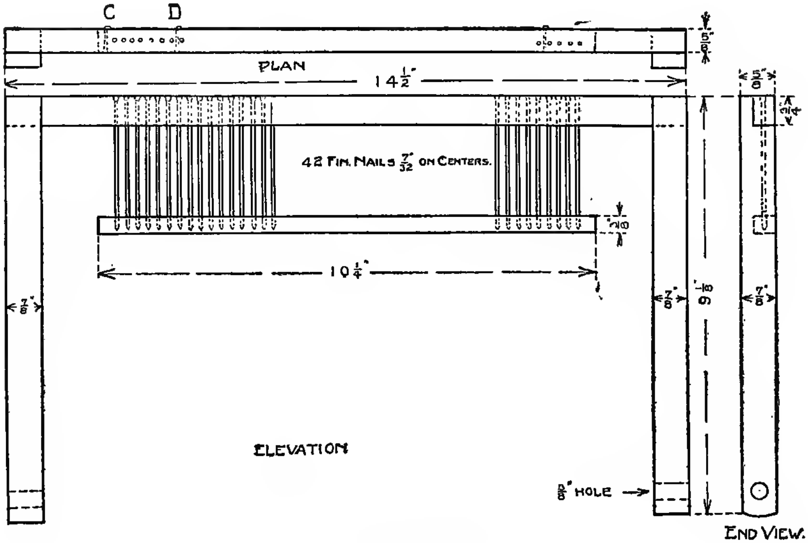


Fig. 212d—Detail of Batten

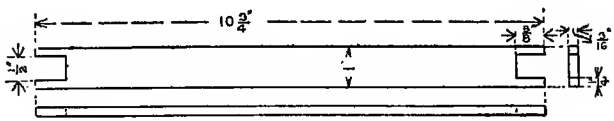


Fig. 212e—Detail of Shuttle

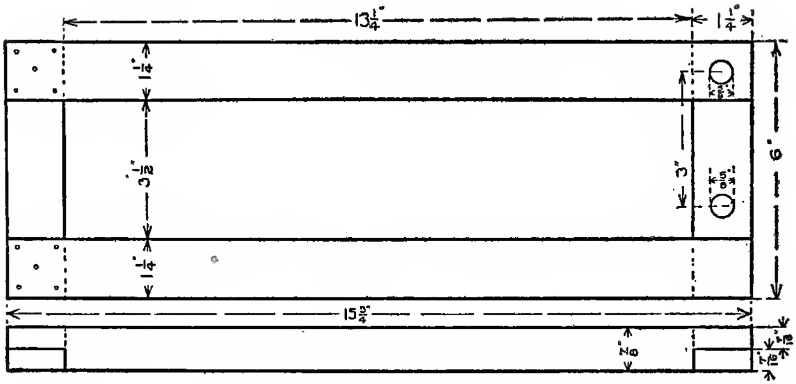


Fig. 212f—Side Piece of Loom. Two Pieces

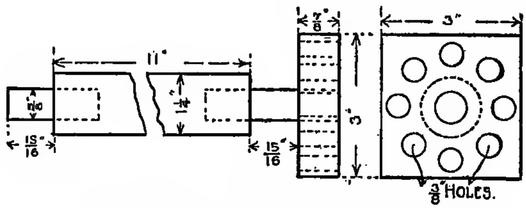


Fig. 212h—Warp and Carpet Rolls. Two Pieces

A canvas is tacked on to the carpet roll and leads up to the front end of the loom. The warp is fastened to a slat across the end of the canvas and the carpet is thus led back to the roll. *G G*, Fig. 212, shows the direction of the canvas.

When the loom is finished a little study will enable one to set it up and weave on it.

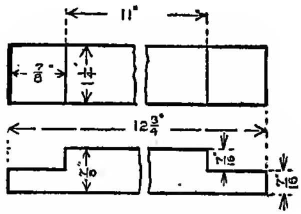


Fig. 212g—End Pieces "A," "B," "C," and "D"

Part 2. For the High-School

General statement.

The work in the high-school can take on at once the more serious consideration of the problem, the material and the tool. If the wood-work began with the seventh grade and has followed through the several groups given in the outline for the grades, a few weeks' review, following closely the sequence of tools and operations given in the first three chapters of the general text, will aid the pupils very much in taking up the larger and more complicated forms of construction. On the other hand, if the wood-work begins in the high-school it will be necessary to begin with the simple forms of construction suggested in the outline for the grade work, the pupil doing enough work in each group to become familiar with the several necessary steps. In many cases, however, the problem may be made larger, more individual choice may be allowed, and the progress may be much faster because of the greater strength and ability of the pupils.

In the following outline for the high-school course, it is assumed that the grade work has been completed.

Group No. 1

All pupils should do the first three problems in this group.

Problem No. 1

Review making piece to three dimensions.

Make a piece to the three dimensions similar to the one ordered on page 3.

Write the detail and mill order.

Lay out and rough saw the stock as directed.

Note carefully the difference between the crosscut and the rip saw, and the reasons for the difference.

Follow carefully the sequence of operations. Order of procedure.

Measure stock.

Examine stock.

Make working face.

Make joint edge.

Plane ends.

Make third and fourth faces.

Take each tool as it is used, adjust it, and study the use of its parts.

Learn to select and sharpen the plane and chisel according to the use to be made of them.

Follow carefully all directions for laying out and testing lines and surfaces.

Problem No. 2—The Lap Joint

Saw the stock from the piece made in the first problem. Review lap joint.

Study the method of stating the problem by the mechanical drawing.

Make a mechanical drawing of the separate parts of the marking gauge, putting in all necessary dimensions. Make an assembly drawing of the gauge without dimensions.

Make the Lap Joint as directed on pages 35 to 46, inclusive.

Study the uses and care of the chisel.

Read what is said about "Cutting or Edge Tools," on pages 90, 91, and 92. Take a knife and make the cuts to prove what it said.

Problem No. 3—The Through Mortise and Tenon

Make the mortise and tenon joint as directed on pages 48 to 56 inclusive. Saw material from the piece made in the first problem. Review mortise and tenon.

Note carefully the method of laying out the joint.

Chisel the material from the mortise.

Pay particular attention to the manner of holding the chisel for the paring and the vertical cut used in chiselling the sides and end of the mortise (page 54, Figs, 70*i*, and 70*j*).

Group No. 2—A Group of Suggestive Problems

Use mechanical judgment.

When beginning any problem, study the parts, note which require accuracy and which do not need to be so carefully made. For example, the joints in the umbrella stand (pages 181 and 182, Figs. 207, 207*a*, etc.) and the two sides of the legs against which the cross-pieces fit should be very accurate. It is not so necessary that the legs be exactly the same size so long as they look alike when placed in position. The side pieces must all be the same length between the shoulders, but a slight difference in thickness will not detract in the least from the value of the piece of furniture.

In other words, use mechanical judgment—take all the time necessary to make an article which will meet every requirement of service, but do not take time to do unnecessary work.

Many of the problems given in the grade work will be suitable for high-school work.

What to make.

The best article to make is something for which the pupil feels a positive need, either for the home or for the school. All pupils will not want to make the same thing, neither will all want to make articles suggested in the different groups.

Statement of problem.

When the mechanical drawing is not given, a complete drawing should be made with all dimensions carefully and plainly written. As a rule, a pupil can make any article for which he can make a complete drawing.

Order for stock.

Continue to write full detail and mill orders and to figure the cost of all material.

Examine the articles of wood-work about the home and school and note how they are put together.

Read carefully Chapter VII, on "Constructive Design."
In connection with finishing any article, read Chapter VI.

Plate Rack

The plate rack is developed much the same as the shelf (pages 173, 174, and 175, Figs. 203 to 203*c*). It is designed to support certain articles and to occupy a certain space. Mechanically it must be large and strong enough to meet both requirements. As a piece of furniture, it must be pleasing in shape and the finish must be in harmony with the surroundings and the nature of the wood. **Requirements of plate rack.**

The accompanying pictures (Figs. 213, 213*a*, 213*b*, etc.) will give some suggestions as to the general form and shape of a plate rack.

Before making a plate rack, find out what dishes are to be placed in it. Measure carefully the space on the wall which the rack is to occupy. If you can, look at a number of plate racks and see how they are put together. **Designing a plate rack.**

The back looks best if put into the side pieces with rabbeted joints. (See page 62, Fig. 85.) The shelves are housed into the side pieces and fastened with screw-eyes and screws. (See page 65, Figs. 103, 104, and 105.)

Design and make a plate rack to meet your own requirements.

Suggestions for Box Making

Boxes may be made in an almost unlimited number of ways and to meet an equal number of requirements. It is seldom that any great number of pupils would want to make exactly the same kind of box. It is therefore left for each pupil to make a mechanical drawing and to put in all needed dimensions for any box he wishes to make.

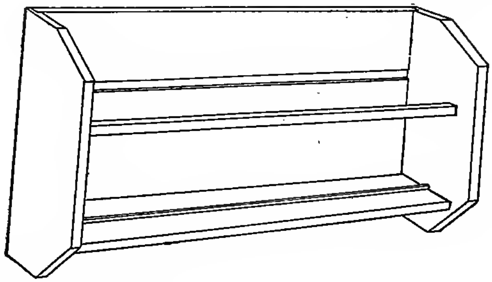


Fig. 213—Plate Rack Which Meets All Mechanical Requirements

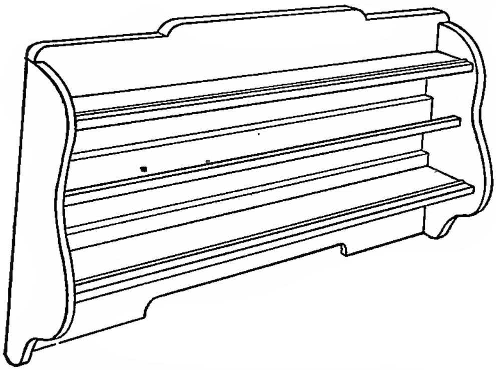


Fig. 213a—Plate Rack Which Meets the Mechanical Requirements as Well as Those of a Piece of Furniture

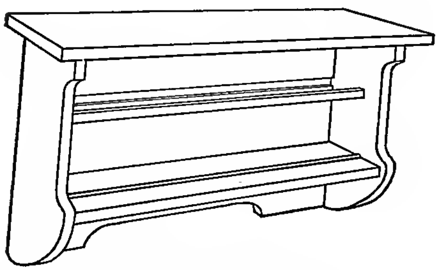


Fig. 213b—Combined Shelf and Plate Rack

Figs. 214 and 214*a* give some general suggestions in box construction. In cases where the cover and the body of the box are made the same width and length, as in Fig. 214, the box may be made in one solid piece and the cover sawed off—this insures a good fit for the cover.

General suggestions.

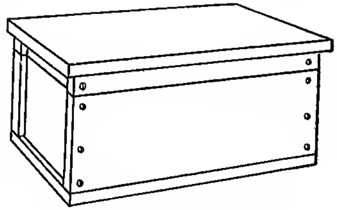


Fig. 214—This Box May Be Made In Various Sizes

In the case of larger boxes, where there is danger of the cover warping, the parts of the side pieces which remain with the cover may be screwed to it from the under side, as in Fig. 214*a*.

Boxes of this type may be made almost any size from a glove box to a large tool box.

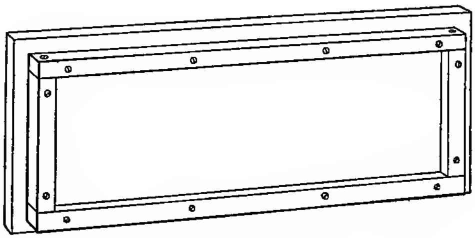


Fig. 214a—Box Cover, Showing Method of Fastening Strips Underneath

Shirt-Waist Boxes

Figs. 214*b* and 214*c* show forms of shirt-waist boxes which are easy to construct and at the same time make an attractive piece of furniture.

If used as a seat, such boxes are generally made eighteen inches high. The covers are cleated underneath to prevent warping.

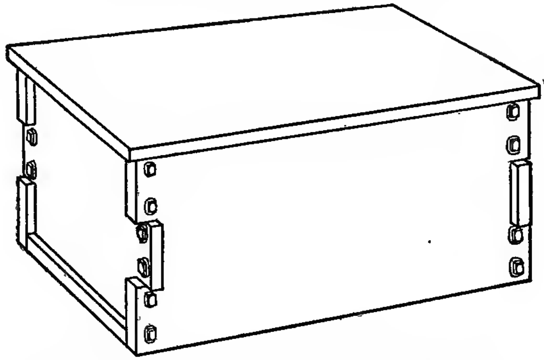


Fig. 214b—Shirt-Waist Box Corners Fastened with ¼″–2″ Lag Screws

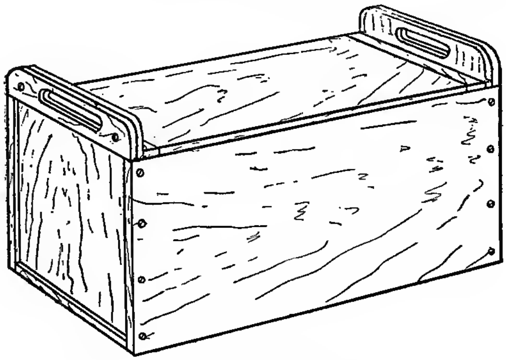


Fig. 214c—Combined Shirt-Waist Box and Seat

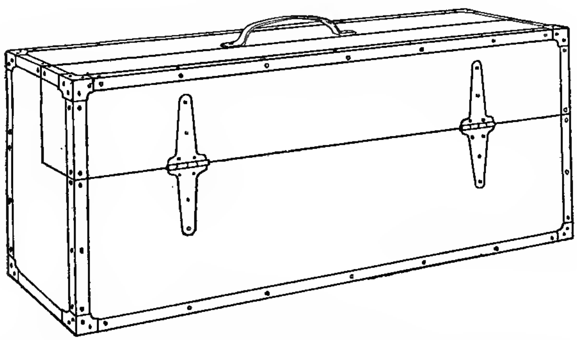


Fig. 214d—Metal-Bound Tool Box for Small Tools. Made of Soft wood

Tool Boxes

Figs. 214*d* and 214*e* show the same box shut and open. The metal bindings on the edges and corners are used a great deal in trunk construction and make it possible to build a strong box from very thin material. Metal bound box.

The box is nailed or screwed together with a plain butt joint (see page 62, Fig. 84), the corners are then bound with either sheet iron, galvanized iron, or brass.

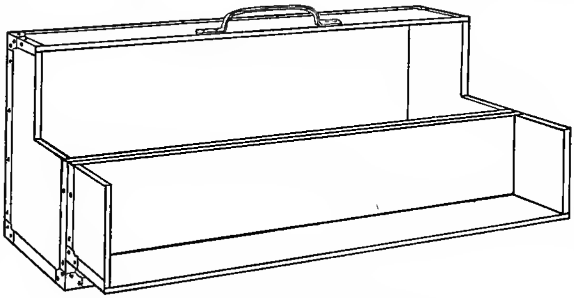


Fig. 214e—Metal-Bound Tool Box—Open

To bend the metal corners.

To bend the metal for the corners, make a line on it with a pencil or knife. Clamp it between two boards with the line along a straight-edge, bend the metal part way down with the hands. Lay a board on it and strike the board with the mallet, thus bending the metal to a sharp, square corner. Do not strike directly on the metal with a hammer or a mallet, for that will make dents in it.

A great variety of strong, useful boxes may be made with this form of construction.

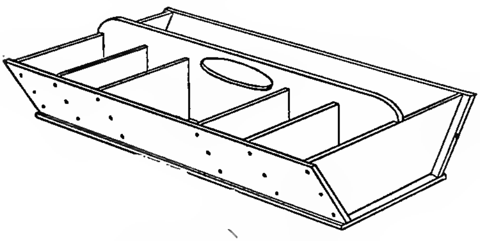
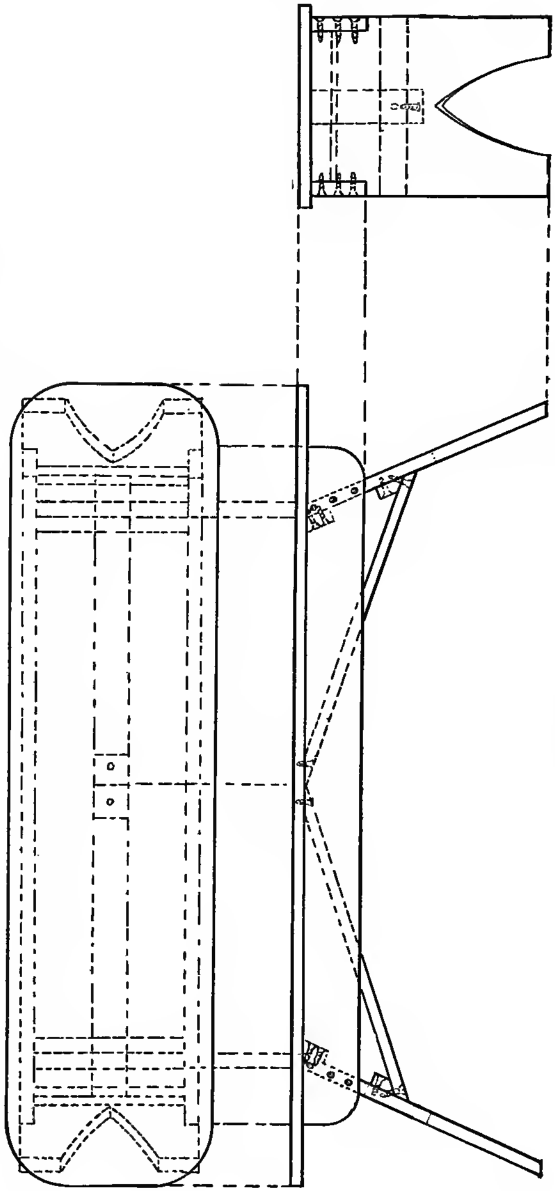


Fig. 215—Tool and Repair Tray

Tool and Repair Tray

Fig. 215 is a tool and repair tray made of soft wood, and may be fastened with nails or screws, or may be metal bound like the last box.

Fig. 216—Utility Bench



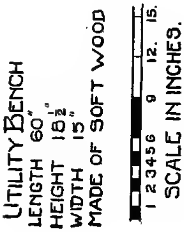


Fig. 216a—Mechanical Drawing of Utility Bench without Dimensions

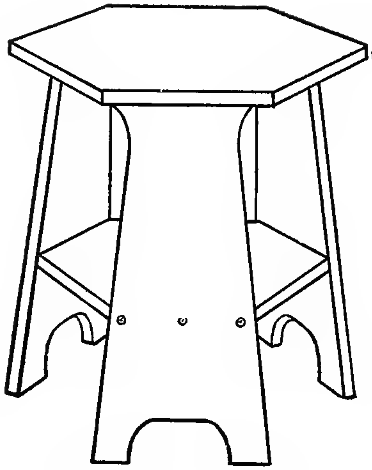
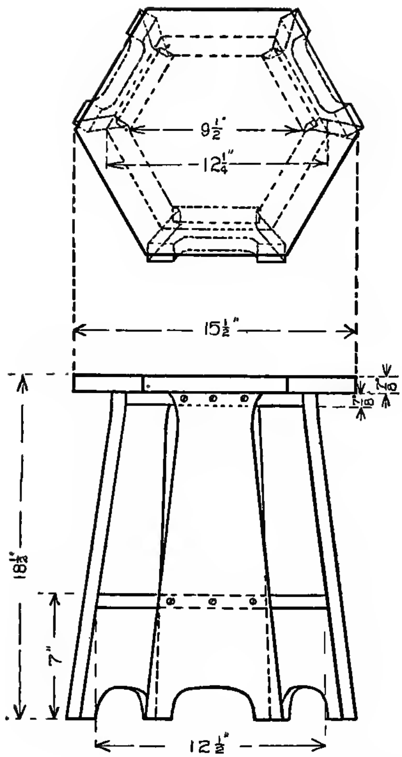


Fig. 217—Tabouret. Hexagon Top

TABOURET
HEIGHT 19"
HEXAGON TOP



DETAIL OF LEG

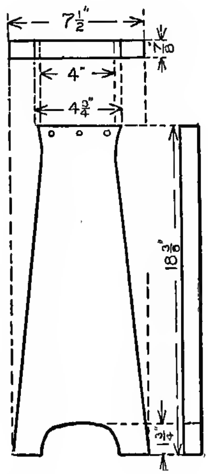


Fig. 217a—Mechanical Drawing of the Tabouret shown in Fig. 217

Such a box should be made long enough to carry a saw of ordinary length.

Utility Bench

The pupils should make a complete drawing of the utility bench and put in all dimensions. Make size and shape of bench to meet requirements.

Tabouret

Figs. 217 and 217*a* are the perspective and mechanical drawings respectively, of a tabouret which is suitable for a large, wide-spreading plant like a palm or fern, etc.

Group 3. A Group of Suggestive Pictures

Figs. 218, 219, 220, and 221 suggest various articles. The pupil choosing to build one of them should make a mechanical drawing of it, select the kind of wood to be used, and make all dimensions and joints to meet requirements.

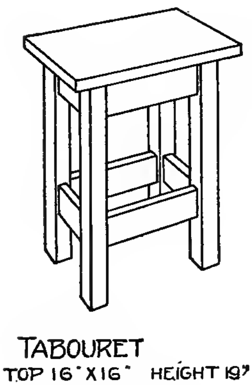


Fig. 218

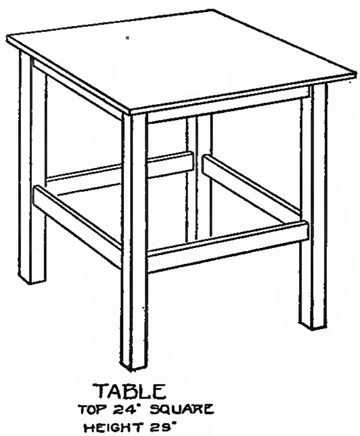


Fig. 219

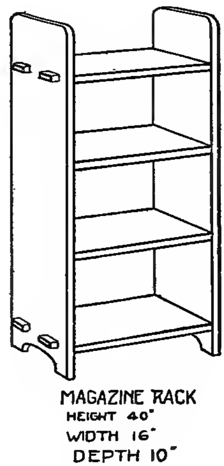


Fig. 220

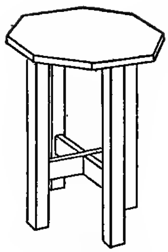


Fig. 221

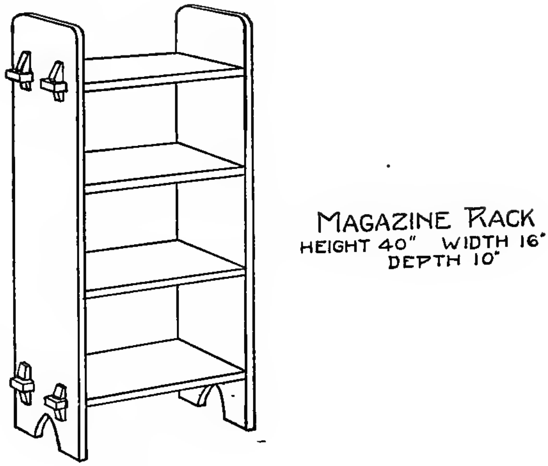


Fig. 222

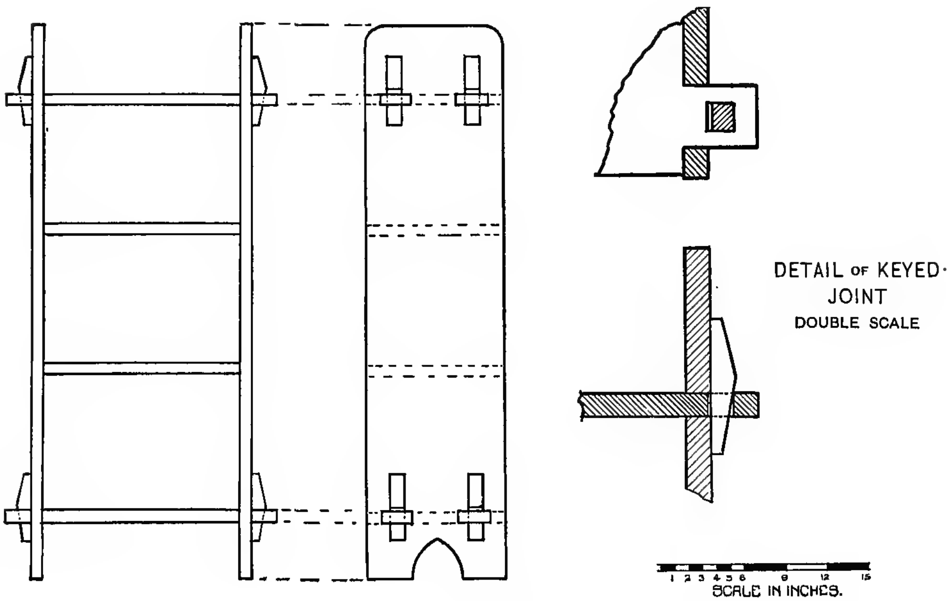


Fig. 222a

MAGAZINE RACK
HEIGHT 45"
WIDTH 16"
DEPTH $10\frac{3}{4}$"

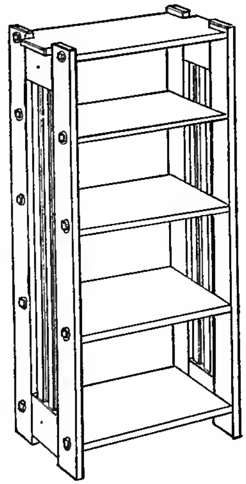
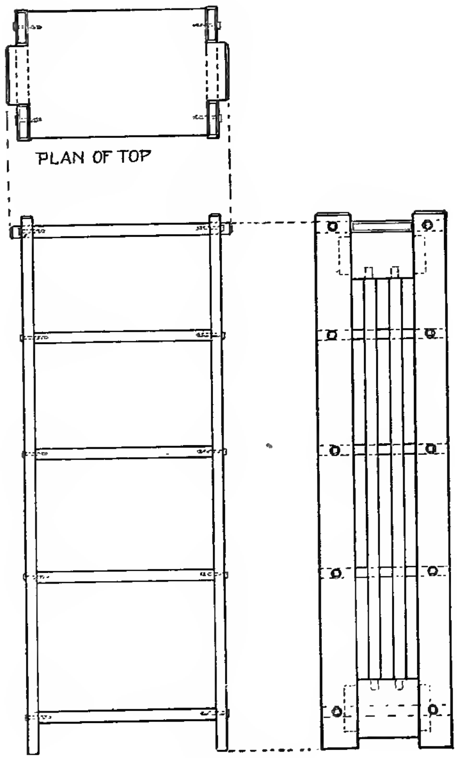


Fig. 223



NOTE.
ALL JOINTS ARE MORTISE AND TENON. SHELVES ARE FASTENED IN WITH $\frac{5}{16}$" x 2" LAG BOLTS
SLATS $\frac{3}{8}$" x 1" STOCK.

1 2 3 4 5 6 9 12
SCALE IN INCHES.

Fig. 223a

Magazine Racks

Figs. 222 and 223 are magazine racks either of which makes a useful and ornamental piece of furniture. Pupils will supply all needed dimensions and draw detail of all joints. The shelves should be farthest apart at the bottom and the space between each pair of shelves should decrease by $\frac{3}{4}''$ toward the top.

Why should there be any difference in the distance between the shelves? Look at doors, bookcases, etc., and see if you can answer this question.

Piano Bench

The piano bench (Fig. 224) may be made with a hinged top and a place for music made by putting in a bottom board between the side and end pieces.

Make a complete drawing, giving detail of parts, etc.

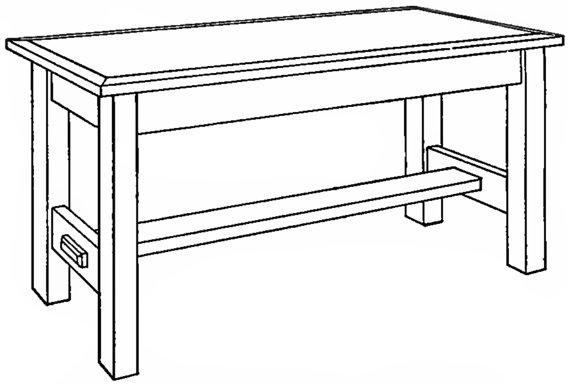


Fig. 224—Piano Bench—Top 15″ x 36″. Height 20″

Library Table

The library table (Figs. 225 and 225*a*) may be made to meet almost any requirements of service. The standard height of a table is thirty inches, and if the top measurements are kept in the ratio

of two in width to three in length the table will always be in good proportion.

The bottom brace (*A*) should be placed two-thirds of the distance from the top of the table down.

The tendency is to make a table of this kind larger than it should

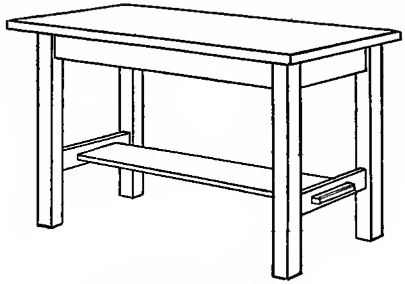


Fig. 225—Library Table *

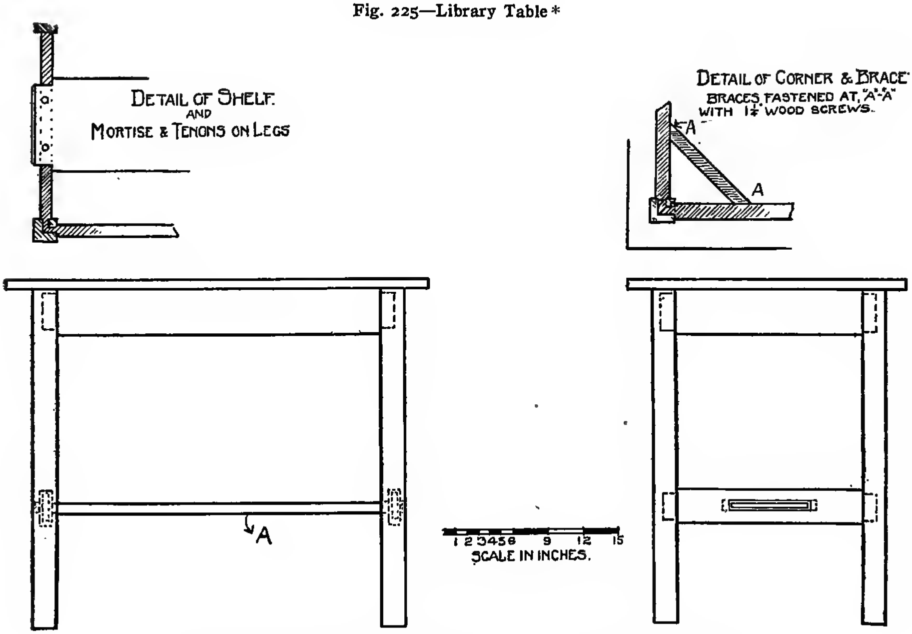


Fig. 225a—Mechanical Drawing of Library Table without Dimensions

* All joints are mortise and tenon. Height of table 30″

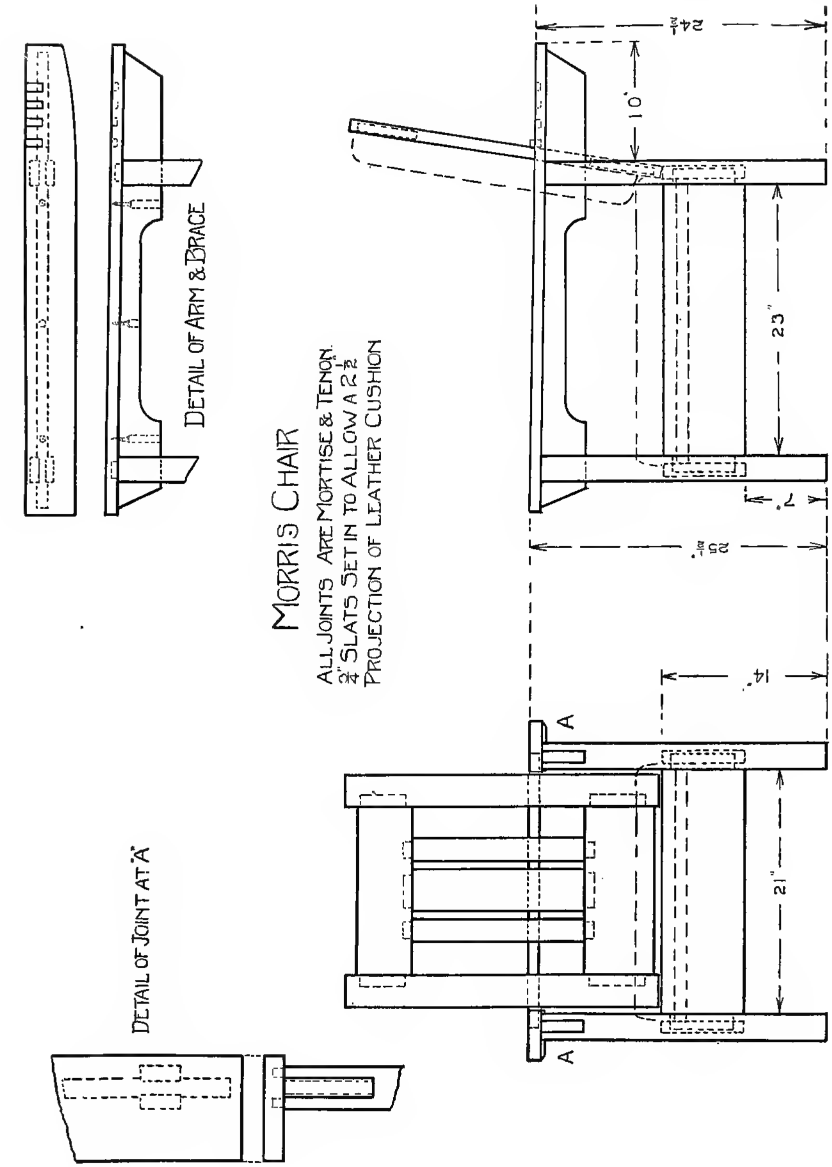

Detail of Arm & Brace
Morris Chair
All Joints Are Mortise & Tenon.
3/4" Slats Set In to Allow a 2 1/2"
Projection of Leather Cushion
Detail of Joint at "A"
A
A
24 1/2
10"
23"
7"
25 1/2"
14"
21"

Fig. 226

be for the space it is to occupy and to make the legs too large and clumsy.

Look at tables and note the methods of fastening top to side pieces. See detail of putting in joints. Then study the place you are going to put the table and make a complete drawing.

In all such constructions one should give careful attention to laying out the work. Lay out all parts and check them before cutting. Make the frame of the table before the top is glued; then fasten the top in place.

Morris-Chair

In Fig. 226 the drawings do not make a complete statement of the problem; they only give the general dimensions. The pupil should make complete detail drawings and put in all dimensions.

APPENDIX

A summary of the course in wood-work may be given as follows;

General Divisions of the Subject-Matter

1. Problem.
2. Material.
3. Tools.

Order of Procedure

1. State Problem.
2. Select Materials.
3. Choose Tools.

Problems are stated either by mill order or mechanical drawing.

Materials are chosen to meet the requirements of the article in which they are to be used.

Order of Tool Work

1. Measuring and Lining.
2. Sawing.
3. Planing.
4. Chiselling.
5. Boring.
6. Special Tools and Operations.

Order of Exercises

1. Cutting Stock.
2. Getting Working Face.
3. Getting Joint Edge.
4. End Planing.
5. Planing to Width.
6. Planing to Thickness.

Joinery

1. Lap Joints.
2. Mortise and Tenon Joints.
3. Butt Joints.

Design

Design all articles for a special purpose. Construction, shape, and finish are determined by the purpose for which the articles are to be used.

Wood Finishing

1. Planing.
2. Scraping.
3. Sand-papering.
4. Staining.
5. Filling. (All open-grain woods.)
6. Varnishing or Painting.

Equipment for Grade Work
Bench

One of the most necessary parts of a wood-working outfit is a strong bench equipped with a good vise. Neither the bench nor the vise should be elaborate. Rapid-acting metal vises are, to be sure, a convenience but by no means a necessity. For the first two years a vise with wooden jaws and a metal screw will answer the purpose very well. If a metal vise is used, the jaws should be faced with wood to keep the edge tools from being dulled by striking against the metal parts.

Unless carving is to be done there is little need for a tail vise on the bench. There are a great many benches on the market made especially for manual-training schools, and, as a rule, it would be better to buy ready-made benches. There is, however, no reason why a good bench cannot be made at home, and if it is equipped with a strong vise it should answer every purpose.

Tool Equipment for Each Pupil

If possible, each pupil should be equipped with a two-inch plane bit and one $\frac{1}{4}''$, one $\frac{3}{8}''$, and one $\frac{7}{8}''$ chisel, which he must keep sharp and be otherwise personally responsible for.

Tool Equipment for Each Bench—To Be Used by All Pupils Who Work at the Bench

One 12″ Metal Ruler. (The ruler should be graduated into sixteenths, eighths, quarters, halves, and into inches, and should not have any other graduations, such as tenths, twelfths, etc., for the extra lines are sure to lead to mistakes in measurements.)

One No. 6 Sloyd Knife.
One 8″ Try Square.
One 8″ Marking Gauge.
One 12″ Back Saw.
One 9″ Smooth Plane Stock Using a 2″ Bit.
One 6″ Screw-Driver. (Champion or equally good.)
One No. 2 Round Hickory Mallet.
One No. 2 Madole Hammer (Bell Face).
One Bench Hook.
One Bench Brush.
One Oil-Stone may be used by the pupils working at two benches.

General Tools for a Class of Twenty-four Grade Pupils

Three 20″ Ten-Point Hand or Crosscut Saws.
Three 22″ Eight-Point Rip Saws.
Six Plane Auger Bit Braces, 8″ Sweep.
One Ratchet Brace, 8″ Sweep.
Three Each, $\frac{1}{4}''$, $\frac{5}{16}''$, $\frac{3}{8}''$, $\frac{7}{16}''$, $\frac{1}{2}''$, and $\frac{5}{8}''$ Solid Centre-Stem Auger Bits, Dowel Lengths.
One Expansive Bit—Small Size.
Two 14″ Jack Planes—2″ Bit.
One Key-Hole Saw.
Two 14″ Turning or Web Saws.
Six Coping Saws. (Use heavy special blades.)
Six Spokeshaves.
Three 12″ Half-Round Wood Rasps.
Six Flat Wood Scrapers.
Six Nail Sets.
Four 24″ Carpenter Squares.
Six 8″ Compasses.
Six Adjustable Block Planes.
Three Screw Countersinks.
Six Tee Bevels.
One 10″ Monkey Wrench.
Three Oil Cans.
One Draw Knife.
Two Each, $\frac{1}{4}''$, $\frac{3}{8}''$, $\frac{1}{2}''$, and $\frac{3}{4}''$ Middle Sweep Gouges.
One Dozen 12″ Wooden Hand-Screw Clamps.
One-Half Dozen 14″ Wooden Hand-Screw Clamps.
One-Half Dozen 18″ Wooden Hand-Screw Clamps.
Use a ready-made cold glue.

High-School Equipment

The bench for high-school work should be large and strong. It should have a heavy top and solid vise. A metal vise with wood-faced jaw will be better than the wooden vises, but it is not necessary to have an elaborate vise.

Individual Tools

The individual tools should be the same as for the grade work, with the exception, perhaps, of one additional plane bit.

Bench Equipment

The bench equipment should be the same as for the grade work, with the addition of a 14″ Jack Plane Stock for each bench.

General Equipment

To the general equipment of the grade work should be added:

Two 24″ Jointer Planes.

One Universal Plough Plane, with attachments.

One Miter-Box and Saw.

One-Half Dozen Three-Foot Adjustable Cabinet-Makers' Clamps.

One-Half Dozen Five-Foot Adjustable Cabinet-Makers' Clamps.

One Glue-Heating Outfit (kind and size determined by the nature and amount of work to be done).

One Grindstone. The size of which will depend on the motive power available.

The above outfit of tools is sufficient for doing good work. It would be possible in many cases to get along with fewer tools and with some kinds of work it would be necessary to have more.

In general it is best to buy very few tools to begin with and add to them as occasion requires.

Always buy good tools. Poor tools are high at any price.

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